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Annual Report on Establishment and
Operation of the Eastern Fine
Particle and Visibility Network

C-E Environmental, Inc., Chapel Hill, NC

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ANNUAL REPORT ON ESTABLISHMENT AND OPERATION OF THE
EASTERN FINE PARTICLE AND VISIBILITY NETWORK

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ABSTRACT

The Eastern Fine Particle and Visibility Monitoring Network (EFPVN) was established to obtain long term, regionally-scaled measurements of visibility and related fine particle characteristics throughout the eastern U.S. The overall goal of the EFPVN is to provide data through which a quantitative assessment can be made regarding trends and causes of visibility impairment in the East. This goal will be achieved through continuous monitoring of atmospheric light scattering coefficient, 24-hour integrated measurements of fine particle mass, elemental composition and optical absorption coefficient, and photographic measurements of visual range taken three times each day. The program is expected to run for five years.

During the first year of the EFPVN, five monitoring stations were established. Three of the stations are located in the southeastern U.S., where airport observations indicate as much as 60 percent reduction in visual range during the past forty years. The remaining stations are located in the Northeast, where long term trends are less evident.

Data collected and processed through July, 1988 are summarized. Light scattering data consists of measurements made with both conventional and insulated integrating nephelometers. The insulated nephelometers maintained the sample temperature typically to within 2.5 degrees Centigrade above ambient.

A limited number of fine particle filter samples were collected and processed through July, 1988. These consist of fifty-two 12-hour integrated samples collected at the Horton Station field site, near Blacksburg, Virginia. During the sampling period, May 3 through May 31, sulfate ion typically comprised about half of the fine particle mass (FPM). FPM and light scattering coefficient (B_{sp}) were related according to $B_{sp} \times 10^4 = 0.032(\text{FPM}) + 0.11$, where B_{sp} is in m^{-1} and FPM is in $\mu\text{g}/\text{m}^3$. The regression coefficient compares well with similar measurements conducted during other field studies. The average particle scattering and absorption coefficients were $0.67 \times 10^{-4} \text{ m}^{-1}$ and $0.04 \times 10^{-4} \text{ m}^{-1}$, respectively.

CONTENTS

Abstract	iii
Figures	v
Tables	vii
1. INTRODUCTION	1
2. CONCLUSIONS	3
3. RECOMENDATIONS	5
4. EXPERIMENTAL PROCEDURES	7
Site Descriptions	7
Description of Measurements	22
Quality Control Procedures	29
Data Aquisition and Management	29
5. RESULTS AND DISCUSSION	33
REFERENCES	57

FIGURES

<u>Number</u>	<u>Page</u>
1 Eastern Fine Particle and Visibility Monitoring Network station locations	8
2 View from the Horton Station, VA monitoring site under conditions of standard visual range equal to 98 (a) and 16 (b) kilometers . . .	10
3 Source emissions over 1000 tons/year within 100 km of Horton Station, Virginia	12
4 View from the Perryville, KY monitoring site under conditions of standard visual range equal to 130 (a) and 15 (b) kilometers . .	13
5 Source emissions over 1000 tons/year within 100 km of Perryville, Kentucky	14
6 View from the Look Rock, TN monitoring site under conditions of standard visual range equal to 67 (a) and 14 (b) kilometers . . .	15
7 Source emissions over 1000 tons/year within 100 km of Look Rock, Tennessee	16
8 View from the Quabbin Summit, MA monitoring site under conditions of standard visual range equal to 99 (a) and 10 (b) kilometers . . .	18
9 Source emissions over 1000 tons/year within 100 km of Quabbin Summit, Massachusetts	19
10 View from the Ithaca, NY monitoring site under conditions of standard visual range equal to 266 (a) and 18 (b) kilometers . .	20
11 Source emissions over 1000 tons/year within 100 km of the Ithaca, NY monitoring site	21
12 Schematic of modified nephelometer system	24
13 Scatterplot of delta temp. vs. relative differences in light scattering measurements made with a modified and conventional nephelometer	26
14 Scatterplot of ambient relative humidity vs. relative differences in light scattering measurements made with a modified and conventional nephelometer	26
15 Light scattering coefficient data recovery for 1988	35
16a Frequency histogram for hourly averages of light scattering coefficient measured at Horton Station during March, 1988	37

FIGURES (cont.)

16b	Frequency histogram for hourly averages of light scattering coefficient measured at Horton Station during April, 1988	37
16c	Frequency histogram for hourly averages of light scattering coefficient measured at Horton Station during May, 1988	38
16d	Frequency histogram for hourly averages of light scattering coefficient measured at Horton Station during June, 1988	38
16e	Frequency histogram for hourly averages of light scattering coefficient measured at Horton Station during July, 1988	39
17a	Frequency histogram for hourly averages of light scattering coefficient measured at Perryville during May, 1988	40
17b	Frequency histogram for hourly averages of light scattering coefficient measured at Perryville during June, 1988	40
17c	Frequency histogram for hourly averages of light scattering coefficient measured at Perryville during July, 1988	41
18a	Frequency histogram for hourly averages of light scattering coefficient measured at Look Rock during March, 1988	42
18b	Frequency histogram for hourly averages of light scattering coefficient measured at Look Rock during April, 1988	42
18c	Frequency histogram for hourly averages of light scattering coefficient measured at Look Rock during May, 1988	43
18d	Frequency histogram for hourly averages of light scattering coefficient measured at Look Rock during June, 1988	43
18e	Frequency histogram for hourly averages of light scattering coefficient measured at Look rock during July, 1988	44
19	Frequency histogram for hourly averages of light scattering coefficient measured at Ithaca during July, 1988	45
21	Scatterplot of fine particle mass concentration vs. light scattering coefficient for May 3 -31 at Horton Station	54
22	Scatterplot of photographic measurements of light extinction vs. nephelometry measurements of light scattering	56

TABLES

<u>Number</u>	<u>Page</u>
1 Start-Up Dates for EFPVN Monitoring Equipment	34
2 Summary Statistics for Light Scattering Measurements	36
3 Summary of Fine Particle Measurements	47
4 Elemental Composition of Particle Samples Collected at Horton Station, Virginia	49
5 Elemental Frequencies in Fine Particle Samples	53

SECTION 1

INTRODUCTION

Visibility impairment is one of the most obvious effects of air pollution. This is particularly true in the eastern U.S. where episodes of widespread regional haze are known to occur^{1,2}. Recent studies have shown that the average visibility in most areas east of the Mississippi River is less than 15 miles. In contrast, average visual range in most of the western U.S. exceeds 25 miles and approaches 100 miles in some pristine areas of the desert Southwest³. Historical records indicate that the intensity of haziness in the eastern U.S. has increased over the past forty years, although the magnitude of this trend varies from place to place and in some areas has leveled during the past decade⁴. The visibility reduction in the East is usually attributed to the concentration of people and industrial activities and the concomitant consumption of energy, especially derived from coal. However, the extent, trends, and specific causes of visibility impairment are not well characterized since much of the previous data, obtained primarily by human observations made at airports, are limited and primarily qualitative in nature.

One of the predominant causes of visibility reduction is the extinction (scattering and absorption) of light by fine particles ($<2.5 \mu\text{m}$ diameter). Results from several field studies show that extinction of light due to scattering increases proportionally to increases in fine particle mass concentrations, although the scattering efficiency of fine particles varies from place to place and exhibits seasonal differences⁵. The relative contributions of light scattering and absorption to total extinction are also known to vary⁶. These variations may be attributed to differences in fine particle characteristics such as size⁷, elemental composition⁵, and state of hydration⁸.

Under the auspices of the U.S. Environmental Protection Agency's, Atmospheric Research and Exposure Assessment Laboratory (AREAL), the Eastern Fine Particle and Visibility Monitoring Network (EFPVN) was established to provide data through which a quantitative assessment can be made regarding trends and causes of visibility reduction in the eastern

U.S. Specifically, the monitoring network was designed to provide long term, regionally scaled visibility and fine particle monitoring data to accomplish the following objectives:

- Determine spatial and temporal variations in the ambient air quality parameters associated with visibility impairment.
- Improve the understanding of visibility - fine particle relationships, especially with regard to fine particle characteristics such as organic and elemental carbon, nitrate, sulfate, and liquid water content.
- Support modeling efforts to identify the sources of visibility degradation (receptor modeling) and to predict visibility impairment (e.g., pollutant dispersion modeling).
- Elucidate the links between visibility impairment, climate modification and acid deposition caused by anthropogenic air pollutants.
- Provide support for decisions regarding ambient fine particle regulation.

To achieve these goals, a network of 10 Tier 1 stations and up to 20 Tier 2 stations has been proposed. However, current funding has limited the network to only five Tier 1 stations and no Tier 2 stations. At Tier 1 stations, color photography and nephelometry are used to measure visibility parameters. Fine particle samples (0-2.5 μm diameter) are collected on filters and analyzed for mass, light absorption, elemental composition, sulfate, nitrate, and organic and elemental carbon. Only color photographic measurements were proposed at Tier 2 stations.

During March - June, 1988, five Tier 1 monitoring stations were established. This document reports the accomplishments achieved in initiating the field program and to develop the data management system required to support the network. Site descriptions and initial data summaries are also presented.

SECTION 2

CONCLUSIONS

Five Tier 1 monitoring stations were established during the first year of the EFPVN program. Three of these stations are located in the southeastern U.S., where airport observations indicate as much as 60 percent reduction in visual range during the past forty years⁴. The remaining stations are located in the Northeast, where long term trends are less evident. In selecting the monitoring sites, emphasis was given to ensure the absence of local pollution sources. The instrumentation at each site include a MRI/Belfort model 1597 integrating nephelometer, a modified Andersen model 245 particle sampler, and an automatic camera system.

The nephelometers deployed in the EFPVN were custom-modified to limit inadvertent sample heating, typically caused by high thermal output of the instrument's light source. Initial testing of a modified nephelometer indicated a reduction in inadvertent sample heating by as much as 10.7 degrees centigrade, when compared to a conventional unit. The modified nephelometers were each equipped to continuously monitor the sample temperature near the exit from the optical chamber. During the summer months, sample heating was contained typically to within 2.5 degrees centigrade above ambient. Later in the year, as ambient temperatures cooled, heat conduction to the heated shelter environment made it increasingly difficult to maintain near-ambient conditions.

Andersen model 245 dichotomous aerosol samplers were modified to (1) provide two separate sample streams with particle cut-off diameters of 2.5 μm ; (2) continuously monitor and electronically record flow rates; (3) continuously monitor and record the filter carousel position, thus indicating the precise start and stop time for each filter exposure; and (4) weather proof the samplers to increase operating reliability under all weather conditions. As the latter three modifications were being performed, a sampler modified only to yield the required particle diameter cut point was deployed at the Horton Station, Virginia field site. Results from these measurements, conducted during May, 1988, indicate the following:

- Fine particle mass concentrations (FPM) ranged from 0.11 to 43.96 $\mu\text{g}/\text{m}^3$, with a mean of 17.55 $\mu\text{g}/\text{m}^3$.
- On the average, Sulfate comprised 53% of the total fine particle mass. This fraction is almost identical to that measured during the Shenandoah Valley field study^{9,10}, conducted during Summer, 1980.
- Particulate Carbon accounted for 11% of the FPM, nearly two times the 6% measured during the Shenandoah Study.
- Fine particle mass concentration and light scattering coefficient (B_{sp}) were related according to $B_{sp} \times 10^4 = 0.032 (\text{FPM}) + 0.11$, where B_{sp} is in m^{-1} and FPM is in $\mu\text{g}/\text{m}^3$. The correlation coefficient for FPM and B_{sp} is 0.89. The resulting fine particle scattering efficiency is $3.2 \text{ m}^2/\text{g}$, which compares well with similar measurements made during previous field studies throughout the U.S.⁶.
- Particle light absorption, measured by the integrating plate method¹¹, was typically 8% of the light scattering coefficient, or 7% of the total particle extinction (scattering plus absorption).

SECTION 3 RECOMMENDATIONS

To provide a complete assessment of visibility and fine particle trends and causes in the eastern U.S., the network must be enlarged. Husar⁴ has identified 10 regions of unique visibility trends in the eastern U.S. Monitoring stations should be established in each of these regions, especially in the Southeast and Gulf states where visibility impairment has increased most during the past forty years.

Light scattering due to liquid water undoubtedly contributes substantially to the total light extinction during conditions of high relative humidity. To provide a complete extinction budget, this contribution must be quantified, either through direct measurement or empirical relationship. Direct measurements can be performed via simultaneous operation of two nephelometers, one with the air stream heated and the other operated at ambient temperature.

Measurements of light scattering coefficient using an integrating nephelometer are subject to errors, since the environment inside the instrument's optical chamber is typically of a different temperature and relative humidity from ambient. Efforts to modify the nephelometers used in the EFPVN have succeeded in reducing the artifact; however, it appears that as long as the nephelometer is housed in an environment which is sheltered from the ambient, variations in the difference between sample chamber temperature and ambient temperature will exist. An alternative is to mount the nephelometer outside. However, this would likely cause additional errors due to subjecting the instrument's electronics to variations in temperature and humidity. Continued efforts toward achieving ambient temperature conditions are recommended.

Measurements obtained thus far indicate that organic Carbon composes nearly 10 percent of the total fine particle mass. Yet, measurement uncertainties, due to loss of volatile matter and collection of gaseous species, limit the accuracy of this estimate. Further study of sampling artifacts, and efforts to limit them are required. The use of a diffusion denuder to remove gaseous organic Carbon upstream from the filter should be

explored.

In many cases, EFPVN stations are collocated with, or nearby, stations in other EPA monitoring networks where additional meteorological and acid aerosol measurements are being made. These additional measurements may be useful in interpreting EFPVN data and in determining light extinction budgets.

SECTION 4

EXPERIMENTAL PROCEDURES

SITE DESCRIPTIONS

Five Tier 1 monitoring stations were established during the first year of the EFPVN program. The locations of the stations are shown in Figure 1. The general location of each site was chosen to be representative of a multi-state region with similar visibility trends. One station, Look Rock, Tennessee, is collocated with an Interagency Monitoring for Protection of Visual Environments (IMPROVE) network station. This arrangement will provide a basis for merging data from the two networks to assess visibility trends throughout the entire U.S. Of the remaining stations, three are collocated with stations in the EPA Dry Deposition Network (DDN) and one is collocated with the Massachusetts State Acid Deposition and NAMS station at Quabbin Reservoir. Collocation with these other programs is designed to benefit the EFPVN by providing supporting pollutant and meteorological data to interpret the results of the visibility and fine particle measurements. Some cost benefits have also been achieved by sharing existing facilities, services and trained operators. In addition, all sites, except for Look Rock, are either collocated with or within 15 km of stations in the EPA Acid-MODES network. The proximity to Acid-MODES monitoring sites will facilitate examination of possible linkage between visibility-impairing aerosols and acid deposition.

Site Selection Procedures

Candidate locations for EFPVN stations were identified by the EPA. The geographical distribution of these locations was chosen so that each of five stations would represent a region of unique visibility trends as determined from airport observations⁴. Each candidate site was surveyed to assess compliance with the following criteria:

- The site is representative in climatology, meteorology, and topography of the region under study.
- An unobstructed vista is available that contains a target (or targets) with the proper inherent color (preferably dark) and the



Figure 1. EFPVN Monitoring Stations and Regions of Similar Visibility Trends as Indicated by Husar et al.⁴

appropriate observation angle(s) and distance(s) for photographic visibility measurements. (Ideally, the camera-to-target distance is approximately 25% of the average local visual range. The camera-target angle should be no more than 3 degrees from the horizontal plane.)

- The site is not impacted by local pollution sources.
- The area surrounding the site is paved or has year-around ground cover to minimize fugitive dust emissions.
- There are no anticipated land-use changes in the vicinity of the site during the projected lifetime of the EFPVN.
- The site is easily accessible to operating personnel and secured from encroachment by unauthorized persons.
- Electrical power is available to operate the monitoring equipment.

Monitoring Sites

Horton Station, Virginia--

The Horton Research Center is located in Giles County, approximately 15 kilometers northwest of Blacksburg, VA, at an elevation of 906 m. This location is in the Appalachian Mountains in southwestern Virginia, on the south-southwest facing slope of Salt Pond Mountain. The station is collocated with DDN site No. 120 and an NADP network site. Acid-MODES site No. 320 is located approximately 6 kilometers to the northeast. Several photographic measurement targets exist to the west-northwest at distances of from 8 to 17.5 kilometers away. Figure 2 shows the view of the selected targets under conditions of standard visual range equal to 98 and 16 kilometers.

The site is surrounded by rural mountainous landscape. The nearest large pollution sources include the Celanese Fibers Co. and the Appalachian Power Co. plants, located at 19 and 28 kilometers to the west, respectively. These plants emit 8355 and 9020 tons of SO_2 annually,



A



B

Figure 2. View from Horton Station, VA monitoring site under conditions of Standard Visual Range equal to 98 (a) and 16 (b) kilometers.

according to the 1985 NAPAP source emissions inventory. Figure 3 shows the relative locations of all stationary pollution sources within 100 km with annual emissions greater than 1000 tons of SO_x , NO_x , or VOCs.

Perryville, Kentucky--

The Perryville, KY EFPVN station is located on the grounds of the Perryville Battlefield in Boyle County, approximately 16 kilometers west of Danville, KY. The station shares the facilities of DDN site No. 129, and is collocated with Acid-MODES site No. 329 and an NADP network station. Photographic measurement targets, Chestnut and Crawford Knob are located at 11.7 and 10.7 kilometers to the southeast, respectively. Figure 4 shows the view of the selected targets under conditions of standard visual range equal to 130 and 15 kilometers.

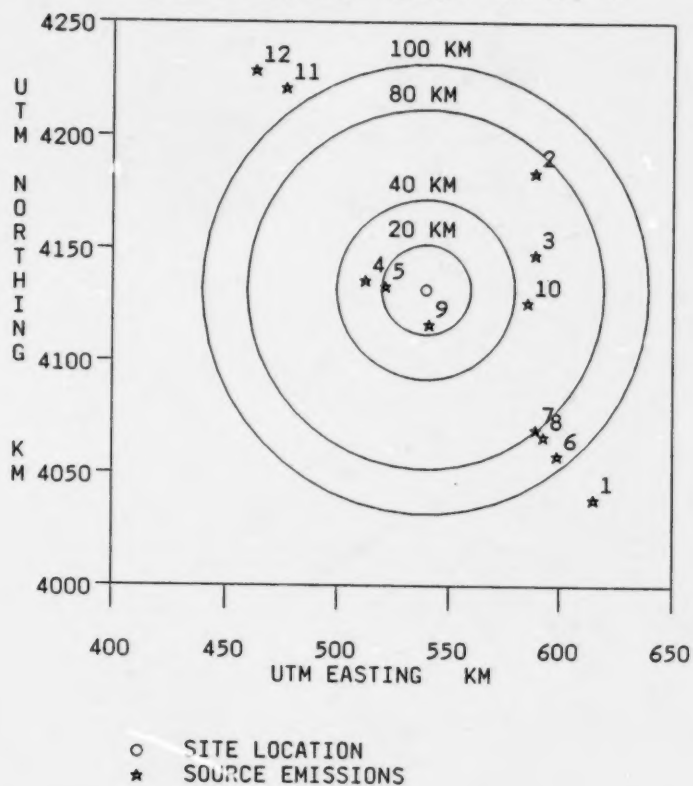
This location is on gently rolling rural terrain, at an elevation of 290 m. The surrounding area is composed primarily of pasture and some agricultural fields. There are no large pollution sources within 20 km of the site. Figure 5 shows the relative locations of all stationary pollution sources within 100 km with annual emissions greater than 1000 tons of SO_x , NO_x , or VOCs.

Look Rock, Tennessee--

Look Rock, TN is located approximately 1.5 kilometers west of the western boundary of Great Smokey Mountain National Park. The station is at the summit of Chilhowee Mountain, a southwest-northeast lying ridge, at an elevation of 790 m. An IMPROVE network station is also operated at this location. A photographic measurement target, Gregory Bald, is located 13.6 km to the southeast. Figure 6 shows the view of the target under conditions of standard visual range equal to 67 and 14 kilometers.

This location is surrounded by undeveloped forest. There are no stationary man-made pollution sources with SO_2 emissions greater than 1000 tons per year within 100 km. Figure 7 shows the relative locations of all stationary pollution sources within 100 km with annual emissions greater than 1000 tons of SO_x , NO_x , or VOCs.

SOURCE EMISSIONS OVER 1000 TONS/YEAR WITHIN
A 100 KM RADIUS OF HORTON STATION, VA



# ON MAP	COUNTY	PLANT	CITY	UTM ZONE	PLANT NAME ADDR	UTM EASTING KM	UTM NORTHING KM	COMPUTED SOX TONS/YR	COMPUTED NOX TONS/YR	COMPUTED VOC TONS/YR
1	NC	3420	0015	17	DUKE POWER CO DAN RIVER STEAM STATION	614.9	4036.6	3592.997	1388.998	5.998
2	VA	0100	0003	17	WESTVACO CORP RIVERSIDE & SHORT STS/COVI	588.6	4183.7	12450.996	5128.996	80.995
3	VA	0460	0003	17	LORE STAR CEMENT, INC RT 779/7 MI W DALEV	588.9	4147.4	8006.998	1307.000	0.000
4	VA	1300	0002	17	APPALACHIAN POWER CO RTS-649 P 460/GLEN	512.1	4135.7	9379.997	5816.997	16.997
5	VA	1300	0004	17	CELANESE FIBERS CO RT 460/4MI E NARROWS/	521.0	4133.0	8354.999	4904.999	5703.999
6	VA	1520	0006	1940	DUPONT DE NEMOURS, E.I. &C/ RT-721/MARTINS	588.8	4057.9	1659.999	1484.999	3.000
7	VA	1520	0012	0280	BASSETT CHAIR CO RT 57/666 BASSETT	589.1	4069.5	47.998	43.998	1533.998
8	VA	1520	0017	17	STANLEY FURNITURE CO RT 57 STANLEYTOWN	592.7	4066.4	97.999	61.999	1485.999
9	VA	2020	0006	17	RADFORD ARMY AMMO FLT RT-114/3MI NE RADF	540.7	4116.1	4064.999	1838.998	8780.999
10	VA	2720	0026	2800	MOHAWK RUBBER CO, THE 1500 INDIANA AVE/SA	585.4	4126.0	0.000	7.999	2523.998
11	WV	0460	0001	17	ELKEN METALS COMPANY - ALLOY PLANT	476.4	4221.0	1995.814	1220.620	1949.333
12	WV	0760	0006	17	APPALACHIAN POWER COMPANY - KANAWHA RIVE	462.9	4228.6	9019.998	6142.998	19.998

Figure 3. Source Emissions Over 1000 Tons/Year Within 100 km of the Horton Station, Virginia EFPVN Monitoring Site.



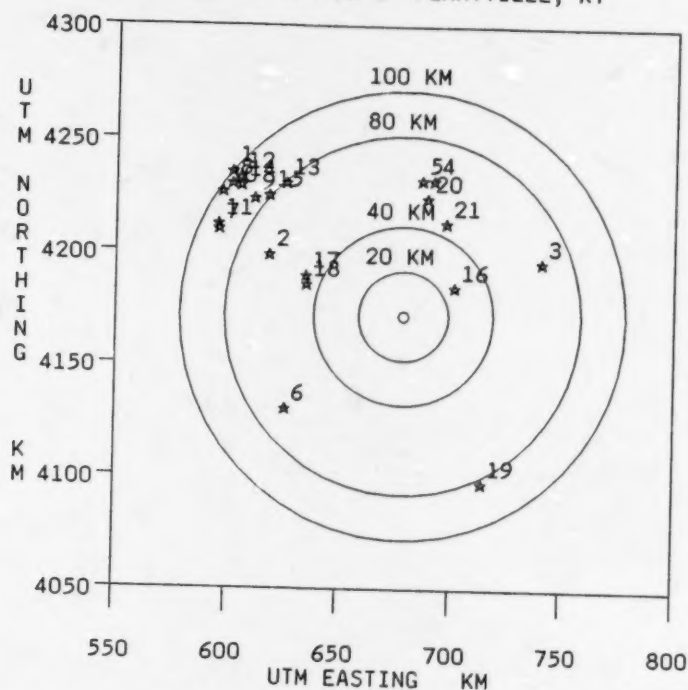
A



B

Figure 4. View from Perryville, KY monitoring site under conditions of Standard Visual Range equal to 130 (a) and 15 (b) kilometers.

SOURCE EMISSIONS OVER 1000 TONS/YEAR WITHIN
A 100 KM RADIUS OF PERRYVILLE, KY



○ SITE LOCATION
★ SOURCE EMISSIONS

# OR MAP	COUNTY	PLANT	CITY	UTM ZONE	PLANT NAME ADDR	UTM EASTING KM	UTM NORTHING KM	COMPUTED SOX TONS/YR	COMPUTED NOX TONS/YR	COMPUTED VOC TONS/YR	
1	IN	1360	0004	2980	16	PUB SERV CO OF IND GALLAGHER STA N.W.A.S.	601.7	4235.4	63810.997	10706.996	35.996
2	KY	0440	0005	16	JAMES S BEAM DISTILLING PLANT 01 CL	618.4	4198.6	0.000	0.000	2209.000	
3	KY	0720	0003	16	EAST KY POWER COOP WILLIAM C DALE	740.8	4196.0	5469.000	2677.000	9.000	
4	KY	1320	0003	16	NATIONAL DISTILLERS, INC. OLD GRANDAD	691.6	4232.0	88.000	34.000	1144.000	
5	KY	1320	0009	1280	ANCIENT AGE DISTILLING CO LEESTOWN RD	686.4	4232.0	78.000	28.000	1875.000	
6	KY	1520	0004	16	TENNESSEE GAS PIPELINE CO HWY 323, GA	625.9	4129.9	0.000	2647.000	64.000	
7	KY	1920	0040	2380	KOSMOS CEMENT COMPANY INCKOSMOS CEMENT D	595.8	4210.1	812.999	1247.000	0.000	
8	KY	1920	0072	2380	E I DUPONT INC LOUISVILLE ASM.	601.5	4230.2	1287.994	1040.994	233.994	
9	KY	1920	0126	2380	FORD MOTOR COMPANY LOUISVILLE ASM.	611.5	4223.6	189.999	111.999	2164.999	
10	KY	1920	0127	2380	LOUISVILLE GAS & ELECTRICCANE RUN	597.3	4226.5	12343.995	8405.995	42.995	
11	KY	1920	0186	2380	LOUISVILLE GAS & ELECTRICMILL CREEK STAT	597.3	4226.5	12343.995	8405.995	42.995	
12	KY	1920	0223	2380	REYNOLDS METALS PLANT #1	604.9	4232.9	118783.996	17420.997	122.996	
13	KY	1920	0244	2380	TEXAS GAS TRANSMISSION BLUEGRASS INDUS	625.5	4230.6	0.000	0.000	2556.999	
14	KY	1920	0870	2380	EARLY TIMES DIST. EARLY TIMES DIS	605.4	4229.3	163.000	73.000	473.000	
15	KY	2740	0001	16	GENERAL ELECTRIC CO. BOILER PLANT	618.0	4225.0	1314.999	694.999	1420.000	
16	KY	3000	0014	16	KENTUCKY UTILITIES CO. BOSTON WELS	701.3	4184.6	54848.000	11195.000	49.000	
17	KY	3000	0020	0140	JAMES S. BEAM DISTILLING JOHN SHERMAN CO	634.9	4189.5	292.000	56.999	1928.000	
18	KY	3460	0005	1280	BARTON BRANDS LTD. OLD CROW DISTIL	635.2	4185.5	0.000	80.000	1824.000	
19	KY	4140	0009	1280	EAST KY POWER COOP	714.2	4097.2	26511.000	7512.000	24.000	
20	KY	4140	0013	3940	NATIONAL DISTILLERS, INC. GTE PRODUCTS CORP.	688.8	4224.0	145.000	0.000	1218.000	
21	KY	4140	0013	3940	GTE PRODUCTS CORP. GTE PRODUCTS CO	697.4	4213.1	33.000	0.000	1218.000	

Figure 5. Source Emissions over 1000 Tons/Year Within 100 km of the Perryville, Kentucky, EFPVN Monitoring Site.

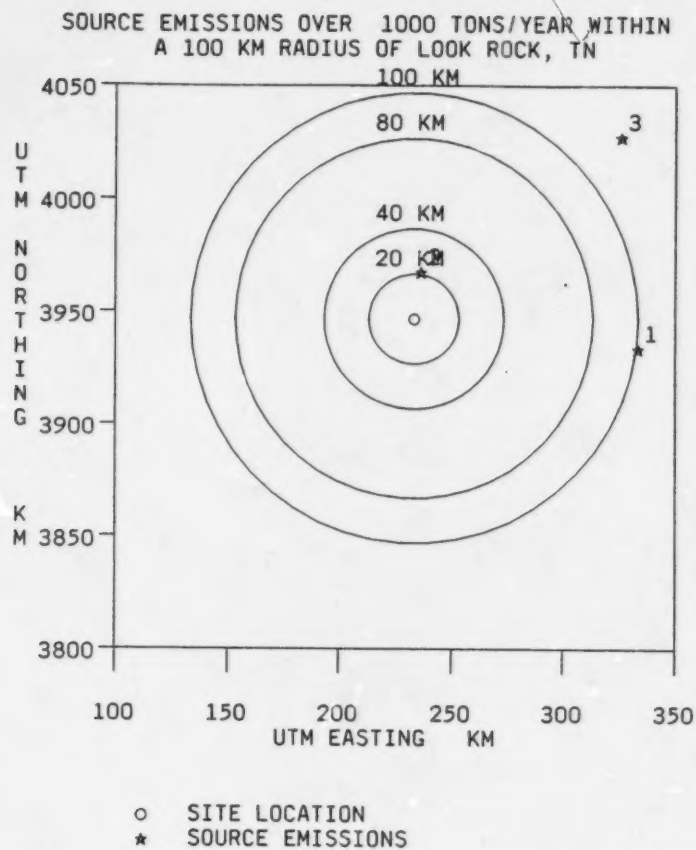


A



B

Figure 6. View from Look Rock, TN monitoring site under conditions of Standard Visual Range equal to 67 (a) and 14 (b) kilometers.



# ON MAP	COUNTY	PLANT	CITY	UTM ZONE	PLANT NAME ADDR	UTM EASTING KM	UTM NORTHING KM	COMPUTED SOX TONS/YR	COMPUTED NOX TONS/YR	COMPUTED VOC TONS/YR
1	MC	1860	0159	17	CHAMPION INTERNATIONAL CORP CANTON	333.2	3933.7	12376.000	7185.462	621.420
2	TH	0180	0090	0020	ALUMINUM CO OF AM NORTH FLT ALCOA 37701	236.1	3947.3	149.999	2302.999	250.999
3	TH	1380	0007	2940	TVA JOHN SEVIER ST FLT ROGERSVILLE 37857	325.8	4027.4	50506.000	14905.000	77.000

Figure 7. Source Emissions Over 1000 Tons/Year Within 100 km of the Look Rock, Tennessee EFPVN Monitoring Site.

Quabbin Summit, Massachusetts--

Quabbin Summit, MA is located approximately 30 kilometers northeast of Springfield, MA, at an elevation of 310 m. The EFPVN shares the facilities of the Massachusetts State NAMS station and is collocated with Acid-MODES site No. 393. The photographic measurement target, Mt. Lincoln, is located 10 km to the northwest. Figure 8 shows the view of the target under conditions of standard visual range equal to 99 and 10 kilometers.

This location is on the shore of Quabbin Reservoir, a 39 square mile body of water. The surrounding area is protected and preserved for wildlife and recreation. There are no large pollution sources within 20 km. Figure 9 shows the relative locations of all stationary pollution sources within 100 km with annual emissions greater than 1000 tons of SO_x , NO_x , or VOCs.

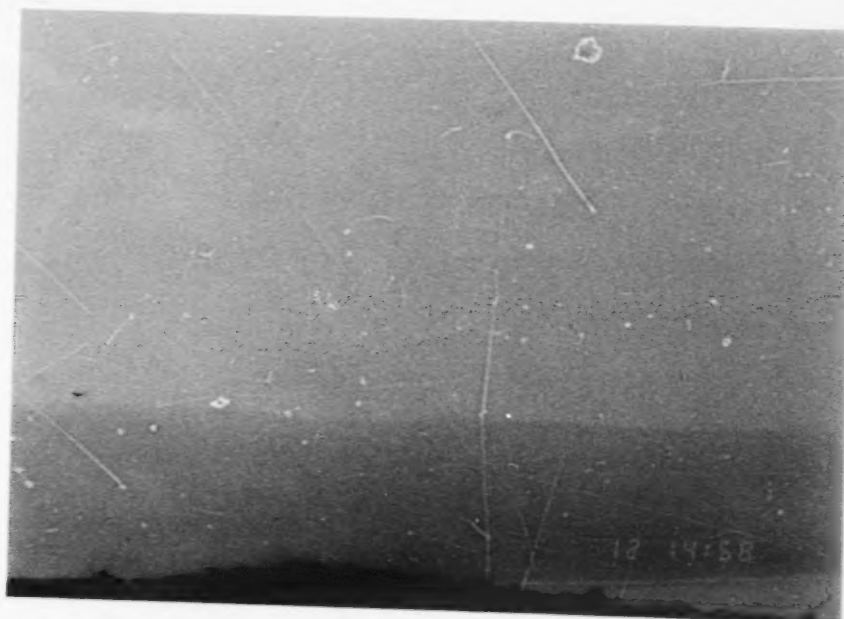
Ithaca, New York--

The Ithaca, NY EFPVN station is collocated with DDN site No. 110. The location is 15 km southwest of Ithaca, NY, at an elevation of 503 m. This location has been the site of a MAP3S precipitation chemistry station since 1976. Acid-MODES site No. 310 is located 15 km to the southeast. The photographic measurement target, Steventown Hill, is located 18.4 kilometers to the east. Figure 10 shows the view of the target under conditions of standard visual range equal to 266 and 18 kilometers.

The site is surrounded by rural landscape composed primarily of deciduous forest and pasture. The nearest large pollution sources include the Cornell University Heating Plant, located 16 km east-northeast of the site, and a 250 mw coal-fired electric generating plant, located 23 km north-northeast of the site. Figure 11 shows the relative locations of all stationary pollution sources within 100 km with annual emissions greater than 1000 tons of SO_x , NO_x , and VOCs.



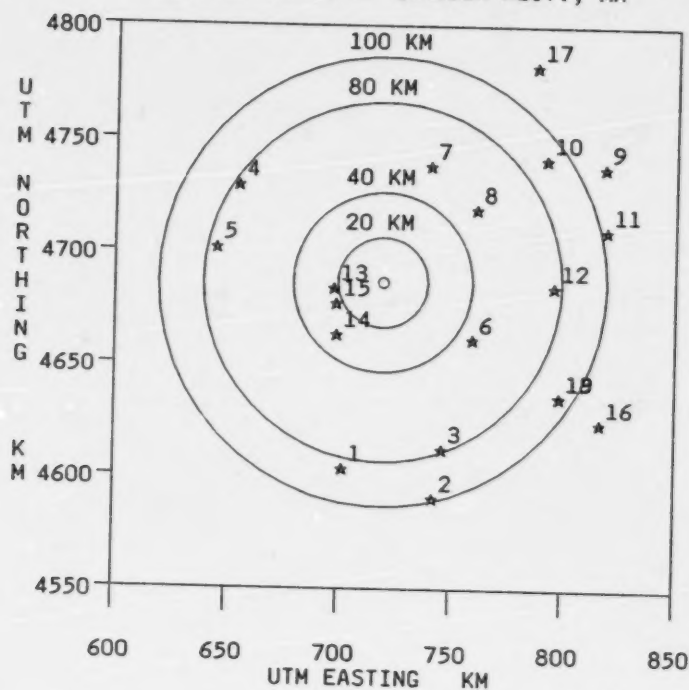
A



B

Figure 8. View from Quabbin Summit, MA monitoring site under conditions of Standard Visual Range equal to 99 (a) and 10 (b) kilometers.

SOURCE EMISSIONS OVER 1000 TONS/YEAR WITHIN
A 100 KM RADIUS OF QUABBIN RESV., MA



○ SITE LOCATION
★ SOURCE EMISSIONS

# ON MAP	COUNTY	PLANT	CITY	UTM ZONE	PLANT NAME ADDR	UTM EASTING KM	UTM NORTHING KM	COMPUTED SO2 TONS/YR	COMPUTED NOX TONS/YR	COMPUTED VOC TONS/YR
1	CT	0565	0874	0578	18	CONN LIGHT & POWER	1866 RIVER RD-MIDDLE	701.9	4603.1	6355.854
2	CT	0725	1505	0620	18	CONN LIGHT & POWER	LATHROP RD-MONTVILLE	742.2	4590.2	7599.893
3	CT	0725	3102	1040	18	FEDERAL PAPER BOARD	ISLAND RD	746.3	4612.0	1031.000
4	MA	0187	0024	1580	18	SPRAGUE ELECTRIC CO.	87 MARSHALL STREET	654.4	4729.2	1429.999
5	MA	0187	0028	1800	18	GENERAL ELECTRIC CO.	180 WOODLAWN AVE.	645.0	4701.4	1189.994
6	MA	0369	0092	2400	19	CRASTON PRINT WORKS	WORCESTER RD	263.0	4660.2	1038.000
7	MA	0369	0141	2246	19	BALDWINVILLE PRODUCT	HILL STREET	740.1	4738.0	1394.000
8	MA	0369	0835	0620	19	JAMES RIVER MILL	810 OAK HILL ROAD	268.4	4717.9	0.000
9	MA	1274	0093	1606	19	A.T. & T. 1600	OSGOOD ST	326.7	4732.6	168.000
10	MA	1291	0134	0660	19	DENNISON MFG. CO.	388 HOWARD STREET	301.1	4738.0	147.994
11	MA	1291	0234	2620	19	GENERAL MOTORS CORP	63 WESTERN AVE	325.9	4704.8	1193.000
12	MA	1291	0427	0660	19	HOLY WATER PWR. M. CO.	TOM RYE. S. SMITH'S FERR	301.0	4681.2	504.000
13	MA	1798	0840	0860	18	WESTERN MASS. ELEC CO	15 AGAWAM AVE	697.5	4683.5	9804.999
14	MA	1798	0193	2126	18	JAMES RIVER GRAPHICS	28 GATLORD STREET	698.8	4662.9	3354.997
15	MA	1798	0193	2126	18	NEW ENGLAND POWER CO	BRAYTON POINT STAT.	317.4	4619.4	491.999
16	MA	2121	0061	2090	19	PUBLIC SERVICE OF NH		299.2	4779.2	77507.995
17	NH	0440	0026	0440	19	NARRAG ELEC. SOUTH ST STA.	PROVIDENCE02903	300.1	4632.2	54472.000
18	RI	0120	0037	0300	19	NARRAG ELEC. MANCHESTER STA.	PROVIDENCE02903	300.3	4632.0	1269.000
19	RI	0120	0039	0300	19					

Figure 9. Source Emissions Over 1000 Tons/Year Within 100 km of the Quabbin Summit, Massachusetts EFPVN Monitoring Site.



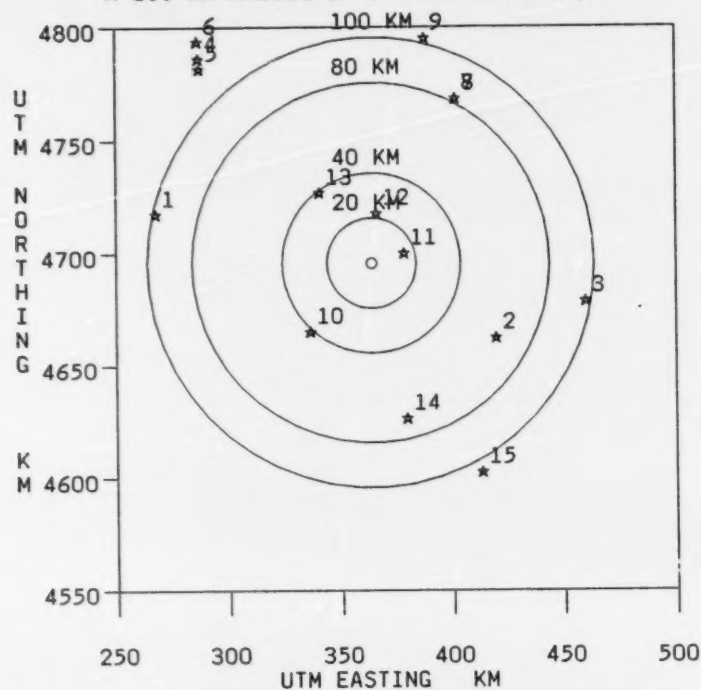
A



B

Figure 10. View from Ithaca, NY monitoring site under conditions of Standard Visual Range equal to 266 (a) and 18 (b) kilometers.

SOURCE EMISSIONS OVER 1000 TONS/YEAR WITHIN
A 100 KM RADIUS OF ITHACA-CT. HILL, NY



○ SITE LOCATION
★ SOURCE EMISSIONS

#	ON MAP	COUNTY	PLANT	CITY	UTM ZONE	PLANT NAME ADDR	UTM EASTING KM	UTM NORTHING KM	COMPUTED SOX TONS/YR	COMPUTED NOX TONS/YR	COMPUTED VOC TONS/YR
1	MA	0369	0027	0620	18	TECHNOGRAPHICS 601 RIVER ST	267.6	4717.5	1383.998	220.998	3.000
2	NY	0640	0292	3380	18	GOUDY STATION	JOHNSON	419.5	4662.4	15219.999	4216.999
3	NY	1080	0083	1080	18	JENNISON STA	RAINBIRD	459.9	4678.6	4634.000	419.000
4	NY	4380	0258	3760	18	KODAK PARK DIV	ROCHESTER	286.9	4786.3	40584.998	14887.999
5	NY	4380	1152	3760	18	EGLE REEBEE STATION	ROCHESTER	287.3	4781.8	7795.000	1038.000
6	NY	4380	1752	4380	18	EGLE RUSSELL STATION	GREECE	286.4	4793.8	24800.000	2976.000
7	NY	5100	0249	6320	18	ALLIED CHEMICAL CORP	SOLVAY	401.6	4768.3	19326.998	4115.998
8	NY	5100	1160	6320	18	GENERAL CHEMICAL CORP. MENLEY	SOLVAY	401.6	4768.3	0.000	1032.000
9	NY	5240	0154	5240	18	MILLER EASTERN BREWERY	VOLNEY	388.0	4795.0	1321.997	254.998
10	NY	6500	0110	6500	18	N Y S GAS AND ELECTRIC	CORNING	336.1	4665.1	6582.000	280.000
11	NY	6720	0001	3300	18	CU CENTRAL HEATING PLANT	ITHACA	378.3	4700.1	1766.999	333.999
12	NY	6720	0120	6720	18	MILLIKEN STA	LANSING	365.9	4717.7	24789.998	7131.998
13	NY	7600	0028	7600	18	NYS ELEC. & GAS	TORREY	340.4	4726.9	20377.000	4565.999
14	PA	1000	0003		18	DUPONT, E. I. DENEHOURS & PHOTO		379.5	4626.4	37.997	61.997
15	PA	9510	0003		18	PROCTER & GAMBLE PAPER FRCHARMIN		413.0	4602.5	2003.096	129.997

Figure 11. Sourc Emissions Over 1000 Tons/Year Within 100 km of the Ithaca, New York EFPVN Monitoring Site.

DESCRIPTION OF MEASUREMENTS

Light Scattering Measurements

Two types of nephelometers were used in the EFPVN. Initially, data were collected at Horton Station, Perryville, and Look Rock using conventional Model 1597 nephelometers. The conventional nephelometer, however, may not always monitor accurately the light scattering properties of the ambient air. This is because the sample air temperature is not preserved from the ambient into the nephelometer's optical chamber. Inadvertent sample heating, by as much as 10 degrees centigrade, may result from the high thermal output of the instrument's light source¹². The sample volume may also be either heated or cooled from ambient temperature by conduction to the interior environment of an air conditioned or heated shelter. Departures from the ambient temperature alter the light scattering properties of the air sample by modulating the amount of liquid water content of the particles as well as altering the phase equilibrium of volatile atmospheric components such as nitric acid and ammonia. Consequently, modifications designed to limit temperature changes were incorporated in nephelometers which were later deployed. These modifications include the following:

- Insulation of all internal and external sample ducts.
- Installation of a muffin fan to withdraw air out of the nephelometer housing (this not only reduces sample heating but also reduces thermal stress on some of the nephelometer components).
- Installation of a radiation shield to reduce heating of the internal sample duct.
- Increase sample flow rate by replacing the sample pump with a commercially available spiral blower with 28 CFM flow capacity.

In addition, the conventional purge air pump was replaced with a spiral blower identical to the 28 CFM sample blower. This decreases the time

required to purge the optical chamber when performing zero checks, to approximately 3 minutes (in contrast to the 15 to 20 minutes required with the conventional purge pump).

Electrical circuitry was also incorporated into the modified nephelometers to permit actuation of various quality control check functions via the site data logger. This not only enables automatic zero and span checks to be performed automatically at prescribed time intervals with data automatically flagged accordingly, but also allows the various check functions to be initiated remotely, at any time, from the Project Management Office in Chapel Hill, NC.

To monitor the heating of the sample volume, temperature sensors were installed in the nephelometer air ducts immediately down stream of the optical chambers. Ambient temperature/relative humidity sensors were also added to the nephelometer systems for comparison with the internal sample temperatures and to aid in data interpretation. The difference between the ambient and nephelometer sample temperatures was continuously recorded by the site data loggers. Figure 12 shows a schematic of the modified nephelometer system. Eventually, all nephelometers used in the EFPVN will be modified in this manner.

To evaluate the effectiveness of the instrument modifications, a modified and unmodified nephelometer were operated side-by-side for two weeks at the Horton Station field site. Results of the intercomparison are moderated somewhat due to less than adequate air conditioning in the shelter housing the nephelometers. Nevertheless, the data indicate that substantial improvements toward approaching ambient conditions are achieved through the instrument modifications and that these improvements measurably enhance data quality.

During the course of the intercomparison, the temperature in the modified nephelometer averaged 13.2 degrees centigrade above ambient. Obviously, in this case, even the modified nephelometer was operating at far from ambient conditions. We attribute this extreme temperature gain to poor air conditioning in the shelter housing the instrumentation. After the completion of the intercomparison, the EFPVN equipment was moved to a better air conditioned shelter, approximately 60 meters from the original

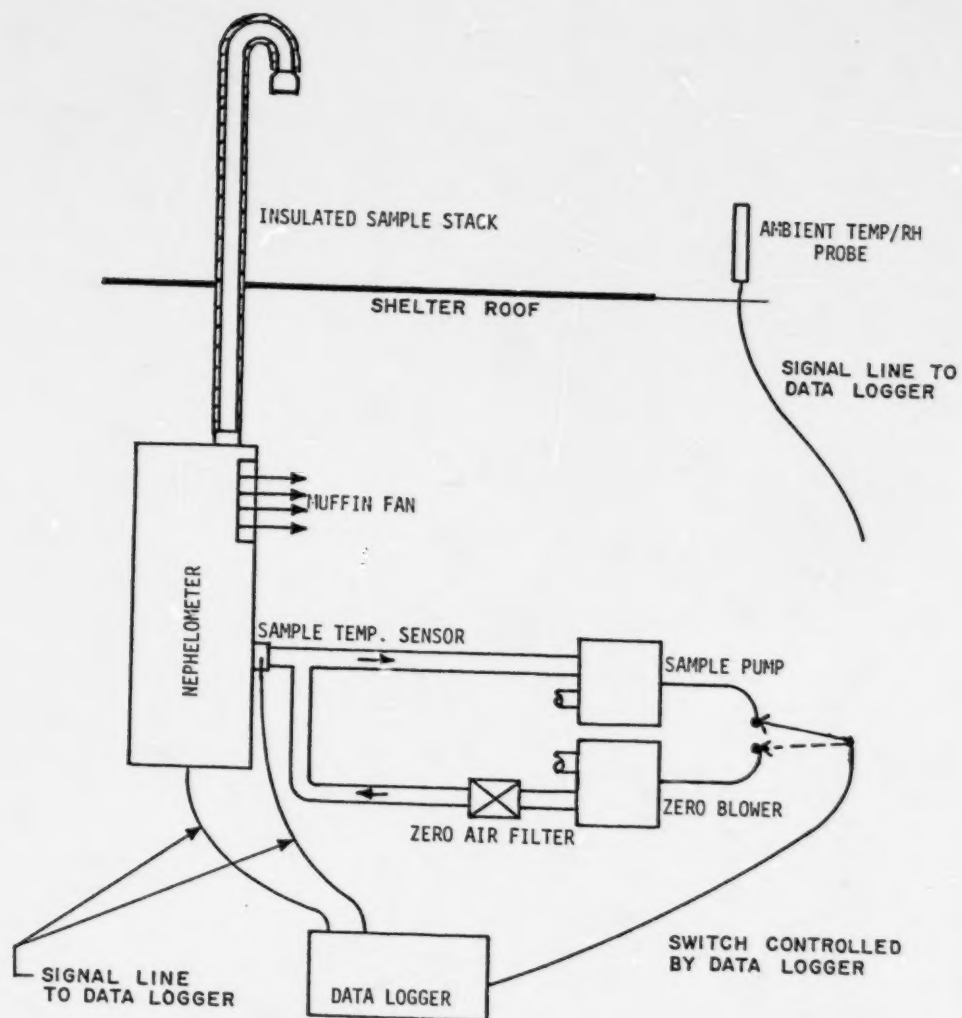


Figure 12. Schematic of EFPVN Modified Nephelometer.

location. Subsequently, the modified nephelometer sample temperature has averaged 1.3 degrees centigrade above ambient. During the intercomparison period, the temperature in the unmodified nephelometer averaged 22.1 degrees above ambient, nearly 9 degrees greater than that of the modified unit.

The average light scattering coefficient measured by the modified nephelometer during the intercomparison, was $1.58 \times 10^{-4} \text{ m}^{-1}$. This value is 12.1 percent higher than the $1.41 \times 10^{-4} \text{ m}^{-1}$ measured by the conventional nephelometer. This is consistent with the goal of the modifications, although the resulting difference in average light scattering coefficients barely exceeds the accuracy of the instruments. Excluding all data for which the most recent instrument background check indicated zero offset greater than 5 percent of the measurement, the relative difference in measurements obtained with the two nephelometers is increased slightly, to 15.9 percent. Due to the extremely large temperature gain recorded in even the modified nephelometer, it would have been surprising to observe much more than this modest difference.

During the intercomparison, the sample temperature of the conventional unit varied between 5.7 and 10.7 degrees centigrade higher than that of the modified unit. To support the assertion that the differences in measurements obtained with the two nephelometers is indeed the result of the modifications performed on one of the units, the relative difference in the measurements (expressed as $(B_{sp} - B_{sp}') / B_{sp}$, where B_{sp} is the light scattering coefficient measured by the modified unit and B_{sp}' is that measured by the conventional unit) is shown plotted against the difference in sample temperatures and against ambient relative humidity (Figures 13 and 14, respectively). Even with both nephelometers operating at far above ambient temperature, the greater the temperature gap between the two nephelometers the greater the resulting difference in light scattering measurements. Figure 14 shows the relationship between relative B_{sp} difference and ambient relative humidity. Although the data exhibits considerable scatter, it is evident that as relative humidity increases above about 65%, the disagreement between measurements obtained with the two nephelometers becomes increasingly greater.

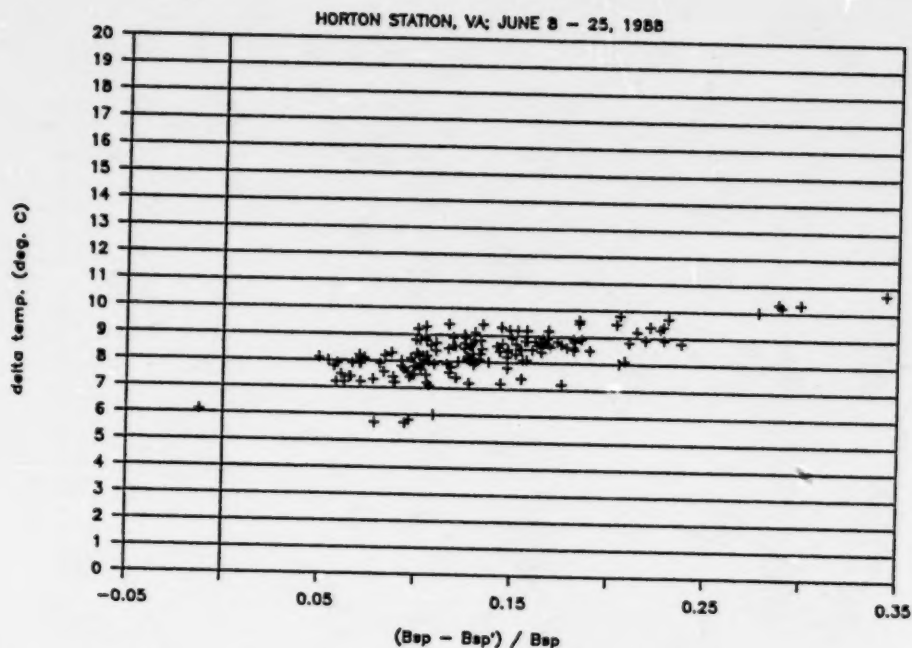


Figure 13. Scatterplot of Delta Temp. vs. Percent Difference in light scattering coefficient measured with modified and conventional nephelometers (see text for explanation).

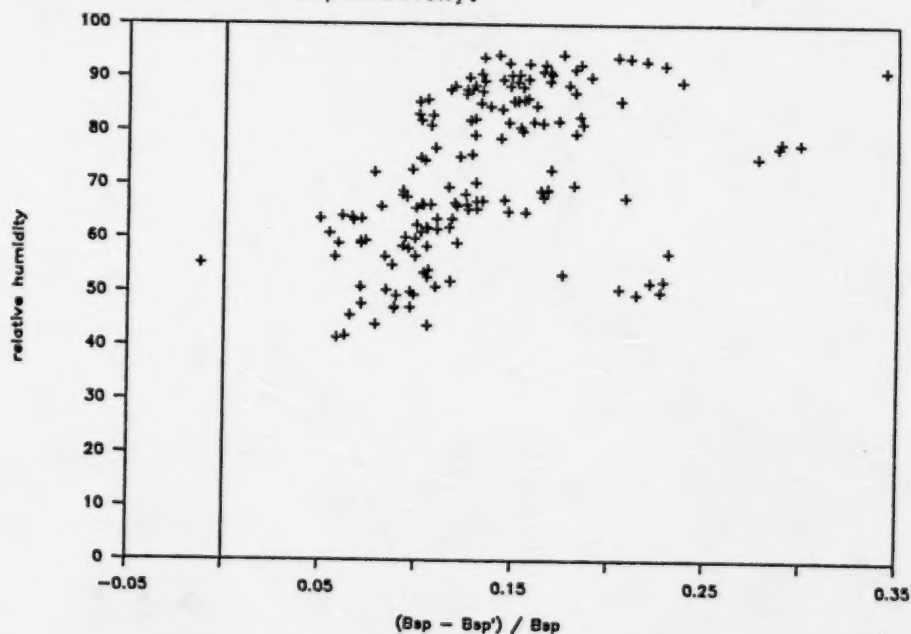


Figure 14. Scatterplot of ambient relative humidity vs. percent difference in light scattering coefficients measured with modified and conventional nephelometers (see text for explanation).

On July 8, the EFPVN instrumentation at Horton Station was moved to a shelter, approximately 60 meters from the original location. From this time through July 31, the modified nephelometer sample temperature averaged 1.3 degrees above ambient, with a standard deviation of 2.89. A modified nephelometer was also installed at Ithaca, NY, where the mean and standard deviation for nephelometer sample temperature gain during July was 2.4 and 1.9 degrees centigrade, respectively. These results indicate considerable improvement toward operating at ambient conditions, however, the range of variation for the measurements at each location indicate that conduction to the internal shelter environment remains a factor in determining the sample temperature.

Fine Particle Characterization

Aerosol sampling was performed using modified Andersen Model 245 particle samplers. The sampler has an automatic sample changer which accommodates 20 pairs of 37mm filters held in circular, polypropylene holders. Electronic circuitry associated with the sample changer permits programming filter change times, sample duration and sampling frequency. Conventionally, this unit operates as a dichotomous sampler. However, to provide two identical sampling channels, the conventional virtual impactor inlet was replaced with two identical inlets, each equipped with a cyclone with a D50 cut point at 2.5 um when operated at 28 liters/minute.

Sampling was performed using Teflon filters (Gelman R2PJ037) in one channel and quartz fiber filters (Pallflex 2500 QA0-UP) in the other. Teflon filters were analyzed for (1) mass concentration using a Cahn Model 27 microbalance, (2) elemental composition by x-ray fluorescence, and (3) light absorption coefficient of particulate deposit using the integrated plate method¹¹. Quartz fiber filters were analyzed for elemental and organic carbon concentration using a thermo-optical method^{13,14}.

Only a limited number of filter samples were collected prior to September, 1988. During the initial planning of field activities for the EFPVN, several design modifications to the Andersen Samplers were envisioned which would enhance quality control and automate sample tracking procedures. These modifications include:

- Replacement of the standard pump with a unit that provides 28 liters/minute flow rate through each channel.
- Addition of Tylan mass flow meters for continuous electronic recording of sampler mass flow rates.
- Addition of a system to provide an electronic signal that indicates filter carousel position. This would provide unambiguous information regarding precise start and stop time for each filter.
- Addition of insulation, heaters, and weatherproofing to increase operating reliability under all weather conditions.

The instrument manufacturer was contracted to perform these modifications. Unfortunately, extraordinary delays in delivery and repeated equipment failures have limited the number of filter samples which have thus far been collected.

Using a sampler which was modified only to the extent that it supplied the required flow to obtain two identical sample streams with 2.5 μ m particle diameter cutpoints, filter samples were collected during the period May 3 - August 1 at the Horton Station field site. Results of analyses for filters collected through May 31 are presented in Section 5. The remaining, fully modified, samplers were received from the manufacturer and deployed during October - November, 1988.

Photographic Visibility Measurements

An automatic camera system, consisting of a 35 mm single lens reflex camera, a 135 mm lens with a UV filter, automatic timing mechanism and a databack to record the time and date of each exposure, was used at each site to obtain photographic visibility measurements. Distant, natural features were photographed at 0900, 1200, and 1500 hours (local time) each day. The resulting color slides were analyzed using a scanning densitometer to determine the film density (at 550 nm wavelength) of the selected target and adjacent sky areas. The target/sky contrast is used to estimate the standard visual range (SVR). In addition, qualitative visibility

information, such as general sky conditions and types of haze conditions (e.g., uniform or layered haze), were derived from the photographic measurements.

QUALITY CONTROL PROCEDURES

Quality assurance and quality control procedures for field and laboratory measurements are described in the Quality Assurance Project Plan for Establishment and Operation of the Eastern Fine Particle and Visibility Network¹⁵.

DATA ACQUISITION AND MANAGEMENT

Continuous field measurements were recorded at each site using an Environmental Systems Corporation (ESC) model AQM-8000B data logger. Each data logger is programmed to receive up to 16 channels of double-ended analog signal inputs, scale and process the data into hourly and 5-minute averages, calculate standard deviations based on 1-minute averages, store data in memory and on RAM cartridges and transmit over dial-up telephone lines to the central computer. In addition, the data logger is equipped with up to 16 output control lines and input status and calibration detection lines which are used to automatically actuate nephelometer dark signal, zero, and span checks and flag the data accordingly. Custom-designed software enables automatic calibration checks to be performed several times each day.

Each data logger is interfaced with a bar-code reader which is used to facilitate sample tracking by digitally linking each pre-coded filter with a coded slot in the fine particle sampler carousel. The sampler carousel position is continuously monitored to determine the precise time period for which each filter is exposed.

The central data management system (DMS) is designed to receive and process hourly and 5-minute data from the site data loggers, 12-hour and 24-hour integrated fine particle data from the analytical labs, and instantaneous, discrete quantitative and qualitative visibility measurements

obtained from color slide photography. The system receives these measurements; processes and screens the measurements to apply data quality flags; loads the data into the EFPVN data base; archives the data; and retrieves the data for subsequent analysis and report generation.

Continuous Measurements Data Collection

Continuous field measurements are transmitted daily via telephone communication from four of the five field stations. Data from the remaining station, Quabbin Summit, MA, are stored on RAM cartridges which are mailed weekly to the central data management center and read by a datalogger connected directly to the central computer (environmental restrictions prohibit telephone service to the Quabbin field site).

Fine Particle Measurements Data Collection

Fine particle data are received from the analytical labs each month on floppy disc and transferred to the central computer for incorporation into the EFPVN data base. The data management software was designed to automatically link the raw laboratory results with associated filter exposure intervals and flow rates (electronically recorded by the field data loggers) to calculate concentrations in units of μ/m^3 .

Photographic Measurements Data Collection

Quantitative and qualitative analyses of color slides are performed by Air Resources Specialists, Inc. (ARS). Data are received from ARS quarterly, and transferred to the central data management system via floppy diskette. The photographic measurements data base consists of discrete instantaneous measurements and is therefore stored separately from the continuous and integrated measurements. This data base stores the station ID, photograph date and time, measured contrasts, computed SVR, daily averages from all observations, meteorological codes, and validation flags.

Automated Data Processing and Validation

Data processing begins automatically after a site is polled for continuous data. Unformatted poll files are converted to readable database format, reviewed for significant events such as power failures, missing data, rate of change, range and threshold exceedances, and persistence problems.

The system is configured to assign a valid (V), invalid (I), or suspicious (S) data quality flag to be associated with the data according to the presence or absence of each significant event. Initially, the data are assumed to be valid. A single data quality flag is associated with each sensor measurement; the highest severity data quality flag configured is assigned if multiple significant conditions are detected for a single measurement. If no data quality assignments are configured, data flagging is disabled.

After processing the data to generate alerts based upon the configured significant conditions and to assign appropriate data quality flags, the Data Management System stores the data in the data base.

Manual Data Review and Validation

During manual review and validation, data quality flags are applied to data associated with anomalous conditions detected by the datalogger, noted by the site operator, and/or identified from results generated by calibration or instrumentation operation check procedures. Manual validation condition codes are used to indicate the reason(s) why data are suspect or invalid. Data identified as suspicious or invalid are only flagged to ensure that associated values are excluded from subsequent data processing and report generation.

To ensure data integrity, an "audit trail" is maintained of all changes made to the EFPVN data base. The audit trail identifies the date and time a change was made, the individual requesting the change, a brief comment stating the reason for the change, and the current data quality flag.

The automated data processing system also calculates data completeness based on raw data capture, data missed, and valid data capture.

SECTION 5

RESULTS AND DISCUSSION

The monitoring equipment installed at each site and dates of operation are listed in Table 1. The measurements conducted at all sites included continuous light scattering coefficient and photographically derived SVR. Fine particle filter samples have been collected and analyzed at all sites except Quabbin Summit, MA. Only samples collected through May 31, 1988 are presented in this report.

LIGHT SCATTERING MEASUREMENTS

Figure 10 illustrates the time periods, through July, 1988, for which valid nephelometry data were collected. Measurements were made with a modified nephelometer during July, at Horton Station and at Ithaca. During June 8 - 26, at Horton Station, measurements were made with both a modified and conventional nephelometer.

Summary statistics for the light scattering measurements are presented in Table 2. Frequency histograms for hourly averages are presented in Figures 16 through 20.

FINE PARTICLE MEASUREMENTS

Fine particle filter samples were collected at Horton Station, Virginia during May through July, 1988. During May, 12-hour integrated samples were obtained twice each day, beginning at 0700 and at 1900 EDT. During the following two months, 24-hour integrated samples were obtained each day, beginning at 0000 EDT. Only samples collected prior to May 31 have been analyzed and are currently available for reporting.

A summary of fine particle data is presented in Table 3. Twelve-hour averages of light scattering coefficient measurements are also presented. Fine particle concentrations ranged from 0.11 to $43.96 \mu\text{g}/\text{m}^3$, with a mean of $17.55 \mu\text{g}/\text{m}^3$. The extreme low value was recorded during the night of May 10 - 11, immediately following the passage of a cold front. The maximum

Table 1
Start-Up Dates for EFPVN Monitoring Equipment

MONITORING STATION	NEPHELOMETER	CAMERA SYSTEM	FINE PARTICLE SAMPLER
Horton Station, VA	2/27/88	3/15/88	5/3/88
Perryville, KY	4/27/88	4/13/88	10/26/88
Look Rock, TN	3/18/88	4/19/88	8/3/88
Ithaca, NY	6/25/88	7/20/88	11/29/88
Quabbin Summit, MA	10/27/88	7/6/88	*1/31/89

*expected start date

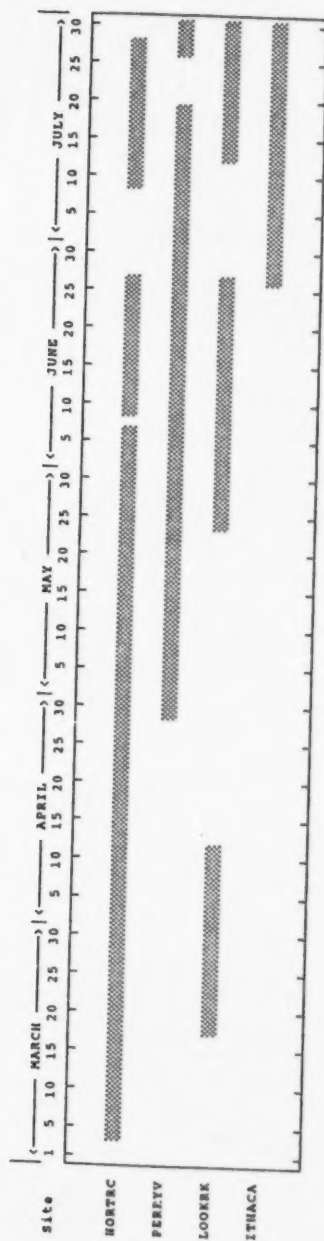


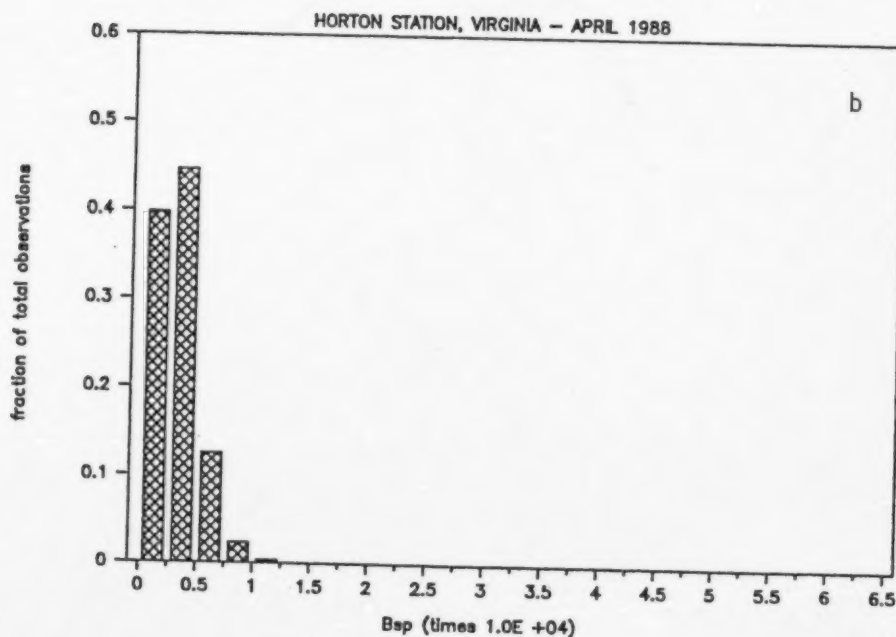
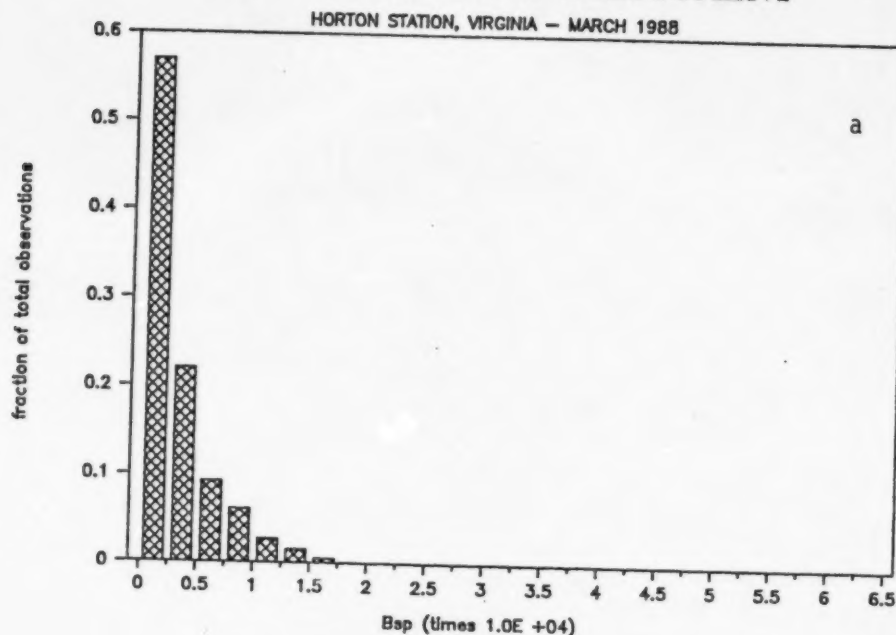
Figure 15. Light scattering coefficient data recovery for March through July, 1988. Gaps in each Bar represent missing data for periods of at least 24 hours.

Table 2
Summary Statistics for Light Scattering Coefficient Measurements ($\times 10^{-4} \text{ m}^{-1}$)

Site	Month	No. Obs.	Mean	Max	Min	Std	Fraction Exceeding $2.5 \times 10^{-4} \text{ m}^{-1}$ (equiv. to 15.6 km SVR)
HOMTRC	MARCH	672	0.31	1.71	----	0.327	0.00
	APRIL	707	0.32	1.17	----	0.193	0.00
	MAY	731	0.65	2.21	0.04	0.396	0.00
	JUNE	572 (341)	1.26 (1.58)	3.54 (4.14)	0.05 (0.08)	0.759 (0.878)	0.00
	JULY	(488)	(2.52)	(6.24)	(0.38)	(1.28)	0.09
PERRYV	MAY	706	0.70	2.34	0.08	0.489	0.43
	JUNE	694	1.10	4.28	0.09	0.834	0.00
	JULY	534	1.33	3.64	0.05	0.793	0.07
LOOKRK ¹	MARCH	320	0.40	2.35	----	0.410	0.00
	APRIL	273	0.19	1.04	0.01	0.169	0.00
	MAY	174	0.47	1.61	0.02	0.381	0.00
	JUNE	579	1.39	3.95	0.08	0.813	0.00
	JULY	469	1.10	2.93	0.03	0.757	0.08
ITHACA		(616)	(1.09)	(4.29)	(-----)	(0.753)	0.03
	JULY						(0.06)

¹ LOOKRK statistics for the following time intervals: March 18-31, April 1-12, May 24-31, June 1-30, and July 1-31.
 ---- Indicates minimum hourly average was below the sensitivity level of the nephelometer.
 () Measurements were made with a modified nephelometer.

LIGHT SCATTERING COEFFICIENT



Figures 16 a-b. Frequency histograms for hourly averages of light scattering coefficient (Bsp) measured at Horton Station during March (a) and April (b).

LIGHT SCATTERING COEFFICIENT

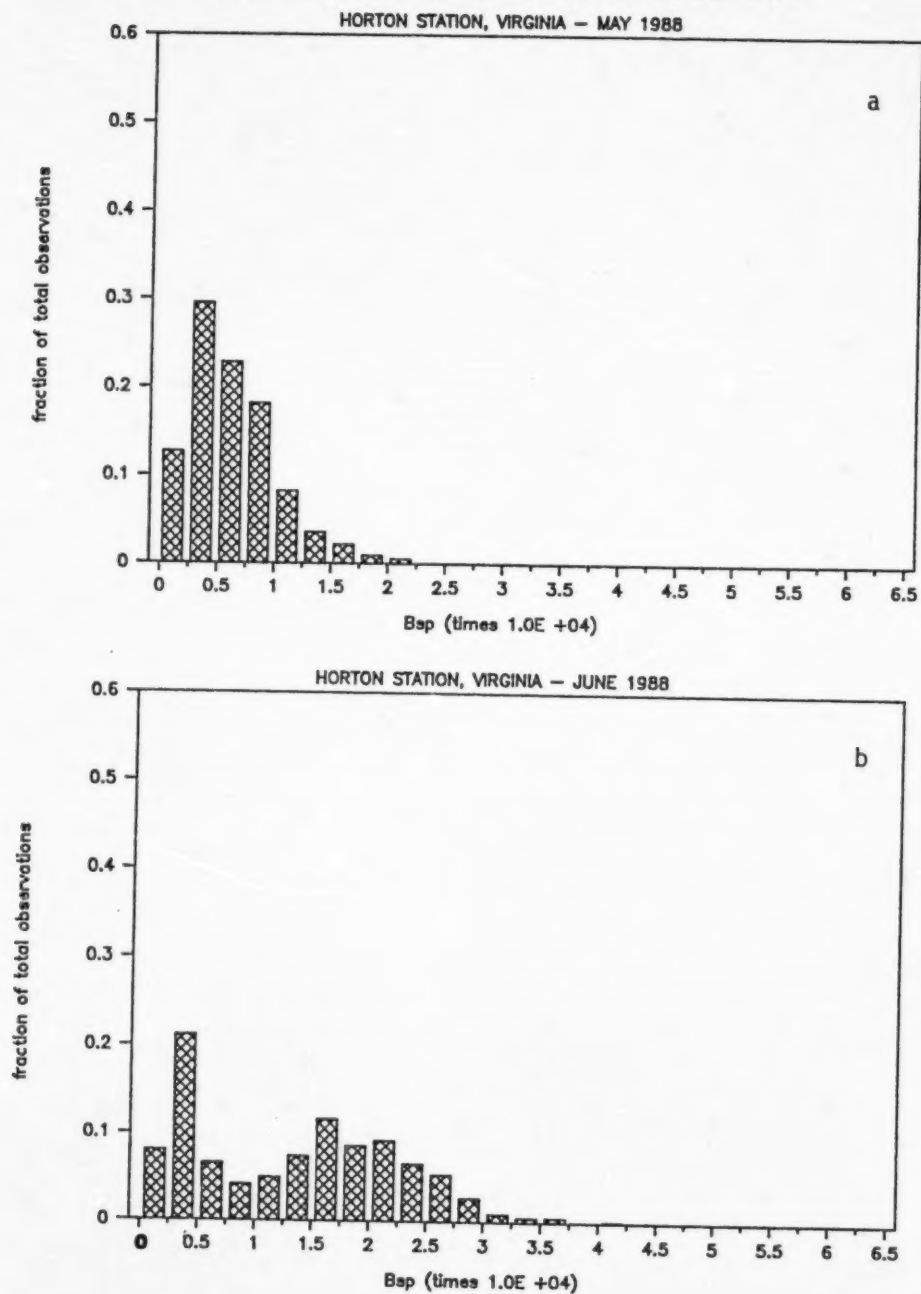


Figure 16 c-d. Frequency hisotograms for hourly averages of light scattering coefficient (Bsp) measured at Horton Station during May (a) and June (b).

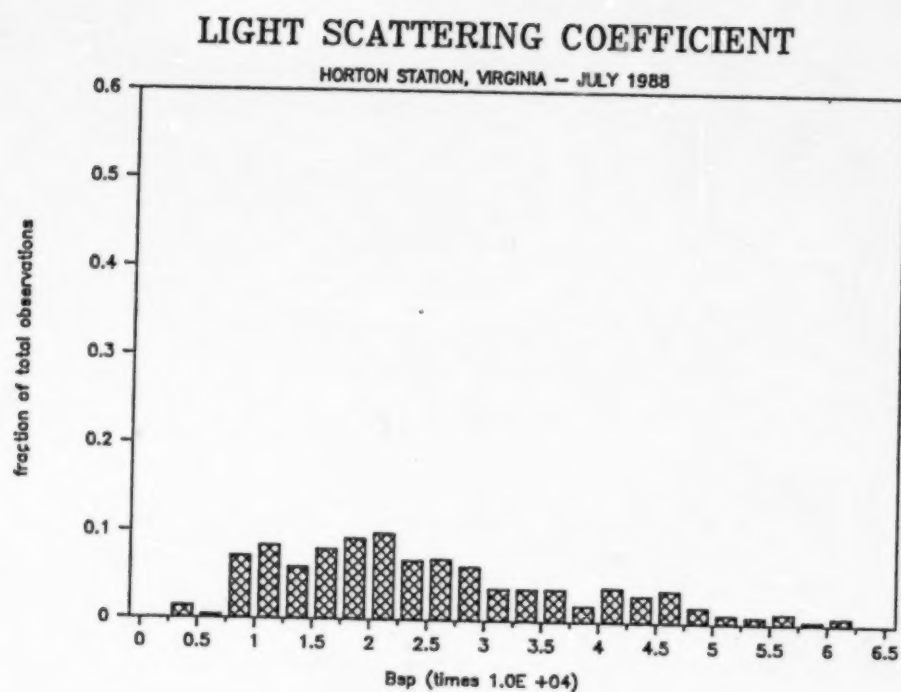


Figure 16 e. Frequency histogram for hourly averages of light scattering coefficient (Bsp) measured at Horton Station during July.

LIGHT SCATTERING COEFFICIENT

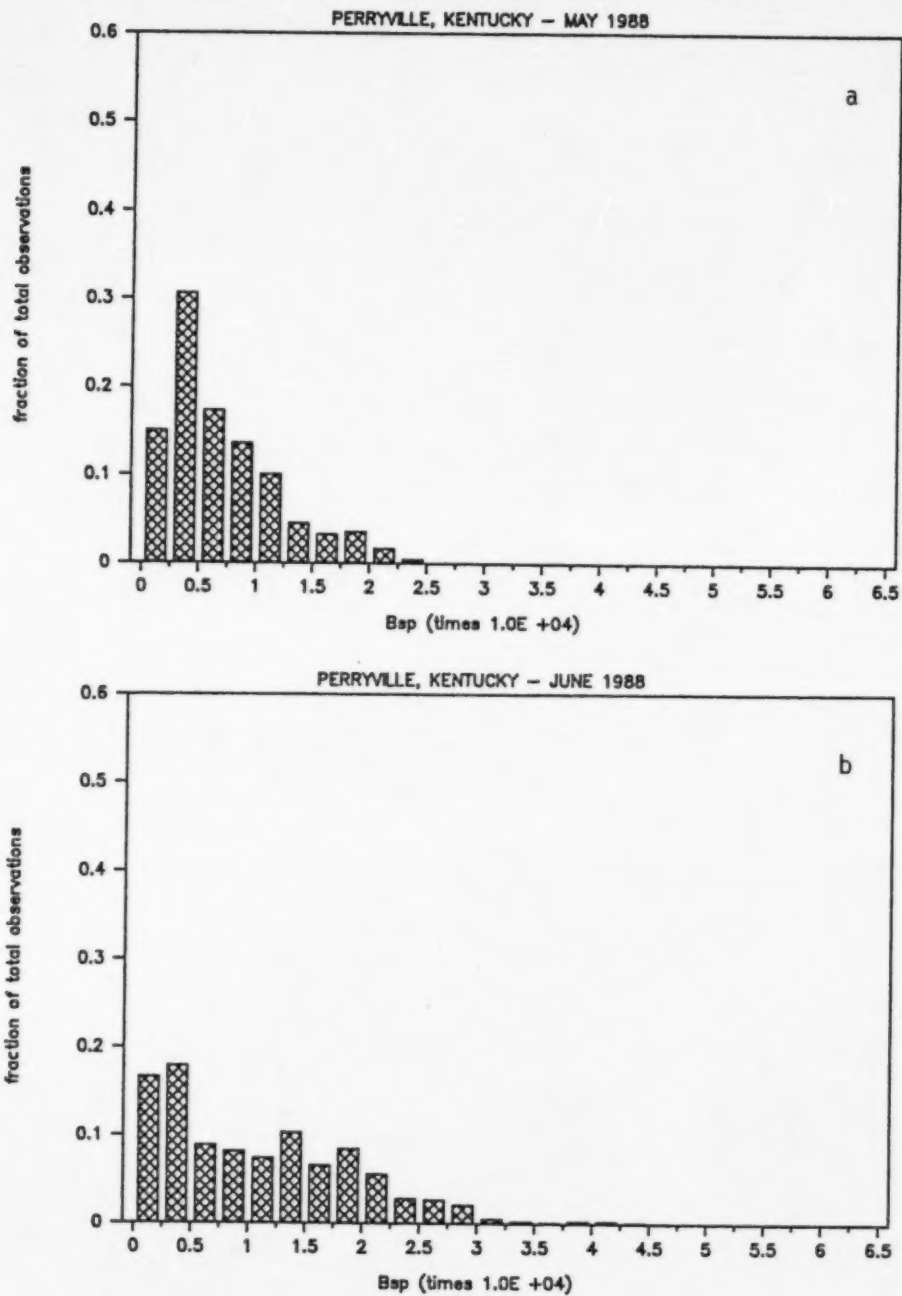


Figure 17 a-b. Frequency histograms for hourly averages of light scattering coefficient (Bsp) measured at Perryville during May (a) and June (b).

LIGHT SCATTERING COEFFICIENT

PERRYVILLE, KENTUCKY - JULY 1988

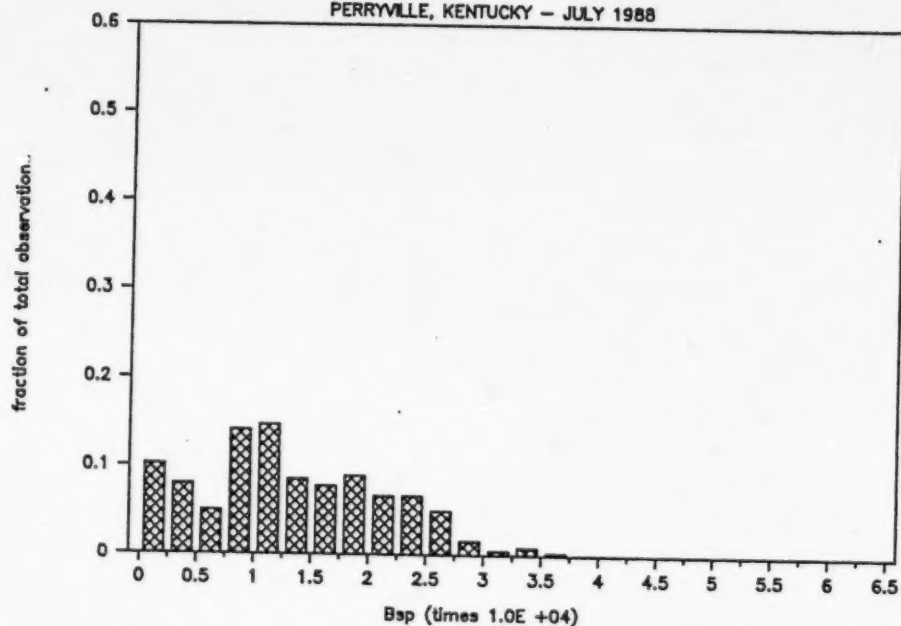


Figure 17 c. Frequency histogram for hourly averages of light scattering coefficient (Bsp) measured at Perryville during July.

LIGHT SCATTERING COEFFICIENT

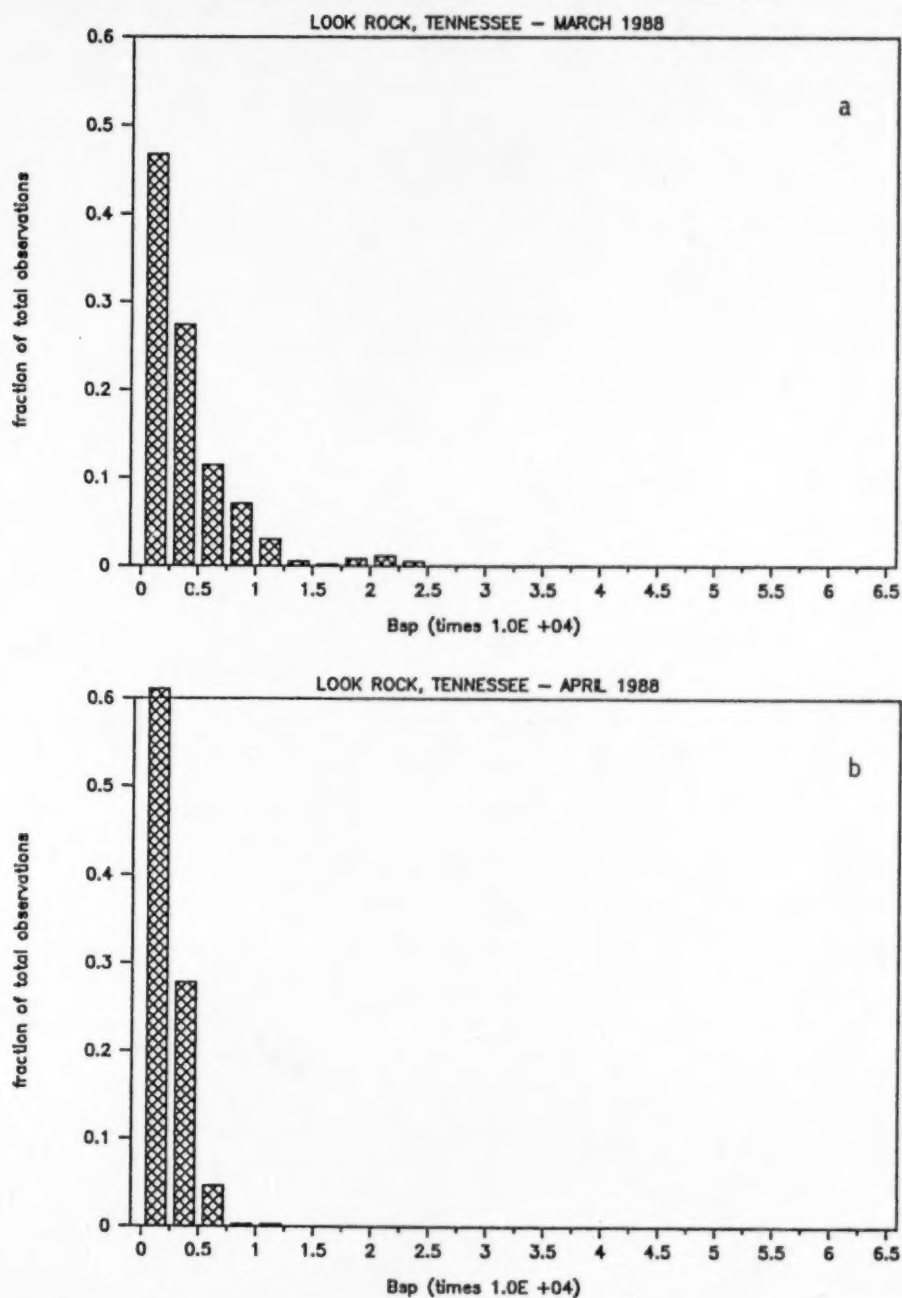
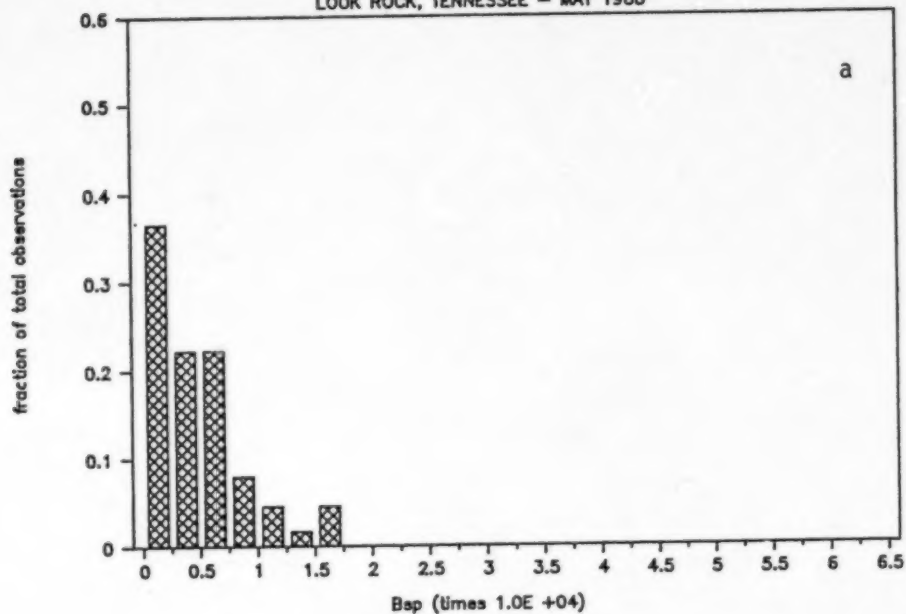


Figure 18 a-b. Frequency histogram for hourly averages of light scattering coefficient (Bsp) measured at Look Rock during March (a) and April (b).

LIGHT SCATTERING COEFFICIENT

LOOK ROCK, TENNESSEE - MAY 1988



LOOK ROCK, TENNESSEE - JUNE 1988

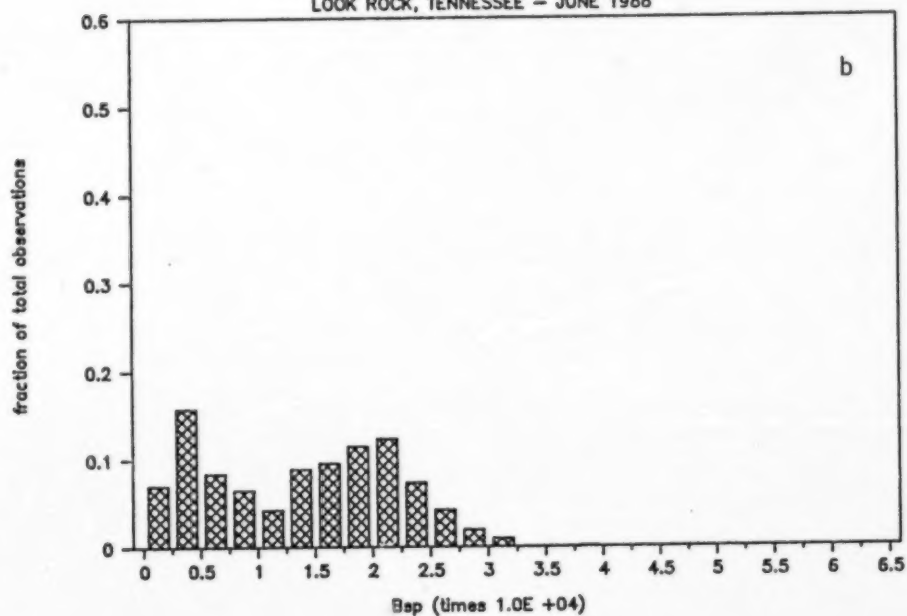


Figure 18 c-d. Frequency histograms for hourly averages of light scattering coefficient (B_{su}) measured at Look Rock during May (a) and June (b)

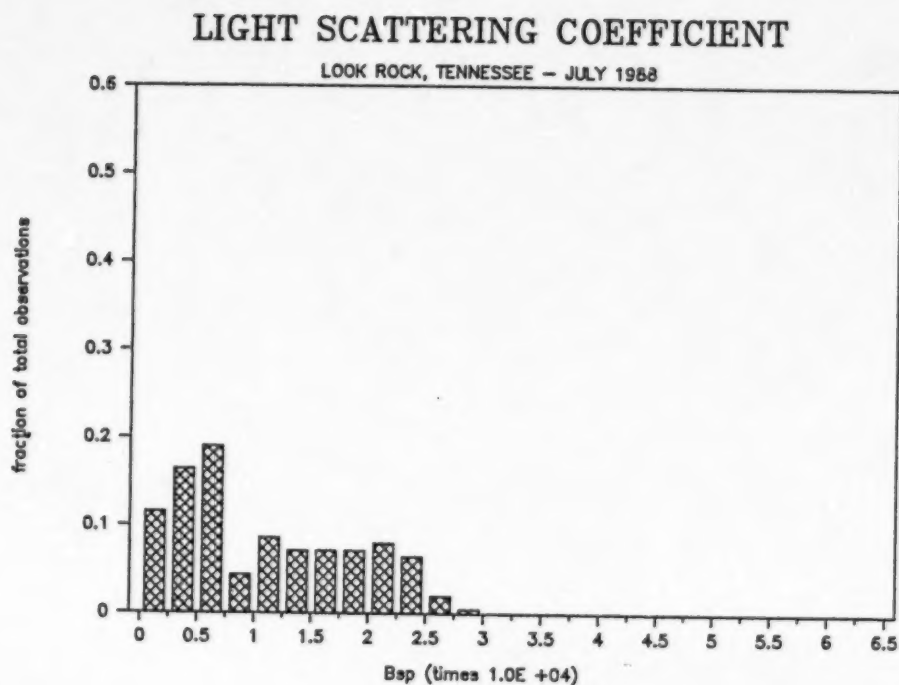


Figure 18 e. Frequency histogram for hourly average of light scattering coefficient (Bsp) measured at Look Rock during July.

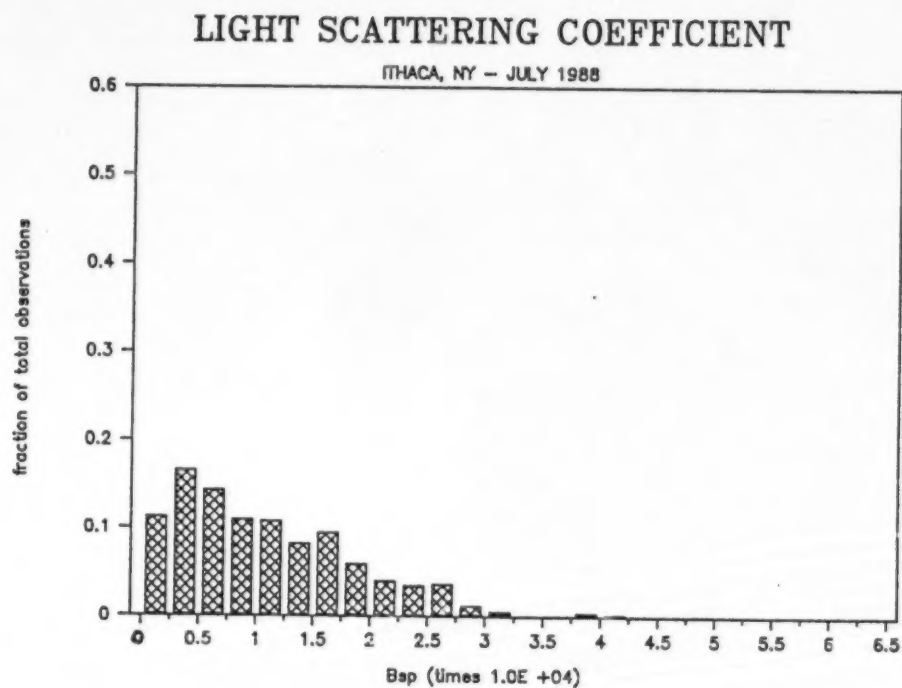


Figure 19. Frequency histogram for hourly averages of light scattering coefficient (Bsp) measured at Ithaca during July.

fine particle concentration occurred on the night of May 30 - 31, following six days of meteorological high pressure stagnation. Elemental composition of the samples are summarized in Tables 4 and 5.

Light absorption coefficient measurements, during May, ranged from below detection level to $0.07 \times 10^{-4} \text{ m}^{-1}$, with a mean value of $0.04 \times 10^{-4} \text{ m}^{-1}$. Measurements were, on the average, 0.08 times that for light scattering, or approximately 7 percent of total extinction. Surprisingly, light absorption measurements showed no correlation with measurements of elemental carbon concentration. The average elemental carbon concentration was $0.23 \text{ } \mu\text{g}/\text{m}^3$. This lack of correlation between elemental carbon and light absorption is perhaps a reflection on the uncertainty associated with measurements of such low concentrations.

The relationship between fine particle mass and light scattering coefficient is shown in Figure 15. The resulting regression equation is $B_{\text{sp}} \times 10^4 = 0.032 (\text{FPM}) + 0.11$, where B_{sp} is in m^{-1} and FPM is in $\mu\text{g}/\text{m}^3$. The R^2 is 0.78, which is slightly lower than one might expect, based on previous studies. However, most previous measurements have been based on dry particle scattering, whereas in this case, no effort had been made to dry the air prior to analysis with the nephelometer. The regression coefficient is a measure of the fine particle scattering efficiency. The scattering efficiency in this case is $3.2 \text{ m}^2/\text{g}$, which compares favorably to measurements previously reported.

In Figure 15, the circled data points represent measurements made between May 25 and 31. These data all indicate individual 12-hour integrated particle scattering efficiencies considerably below that for the remainder of the month. Indeed, considering only data collected prior to May 25, the resulting regression equation is $B_{\text{sp}} \times 10^4 = 0.040 (\text{FPM}) + 0.03$. The r^2 , for May 1 - 24, is 0.80, and the intercept is nearly zero. The average scattering efficiency during this period was $4.0 \text{ m}^2/\text{g}$. In contrast, the regression equation for the period May 25 - 31 is $B_{\text{sp}} \times 10^4 = 0.032 (\text{FPM}) - 0.07$. The r^2 in this case is 0.95, and the average particle scattering efficiency is $3.2 \text{ m}^2/\text{g}$. Although the available data do not support any conclusion regarding the cause of this dichotomy, meteorological records indicate that following a cold front which passed

Table 3
Summary of Fine Particulate Measurements - HORTAC, May 1988

Ending Date/Time	Fine Particle Mass ($\mu\text{g}/\text{m}^3$)	Sulfate Fraction	Bsp^{-1} ($\times 10^{-4} \text{m}^{-1}$)	Bsp^{-1} ($\times 10^{-4} \text{m}^{-1}$)	Bsp/Bsp Carbon ($\mu\text{g}/\text{m}^3$)	Elemental Carbon ($\mu\text{g}/\text{m}^3$)	Organic Carbon ($\mu\text{g}/\text{m}^3$)
5/4 7:00	20.70	0.49	0.93	0.0262	0.03	0.28	1.80
5/4 19:00	20.05	0.47	0.87	0.0256	0.03	0.23	1.64
5/5 7:00	10.16	0.45	0.57	0.0220	0.04	0.13	1.13
5/5 19:00	14.55	0.55	0.56	0.0254	0.05	0.44	0.94
5/6 7:00	4.17	0.57	0.17	0.0182	0.11	0.14	0.35
5/6 19:00	10.48	0.61	0.41	0.0199	0.05	0.24	0.16
5/7 7:00	17.65	0.56	0.8	0.0263	0.03	0.36	1.15
5/7 19:00	10.59	0.43	0.36	0.0266	0.07	0.17	1.81
5/8 7:00	13.48	0.52	0.35	0.0343	0.10	0.19	1.60
5/8 19:00	15.03	0.50	0.56	0.0420	0.08	0.25	2.25
5/9 7:00	18.98	0.45	0.72	0.0418	0.06	0.25	2.49
5/9 19:00	21.50	0.46	1.03	0.0442	0.04	0.28	2.49
5/10 7:00	11.12	0.46	0.51	0.0349	0.07	0.21	1.27
5/11 7:00	0.11		0.21	0.0041	0.02	0.00	0.00
5/11 19:00	12.99	0.58	0.49	0.0376	0.08	0.20	1.20
5/12 7:00	15.40	0.62	0.64	0.0337	0.05	0.60	0.48
5/12 19:00	13.85	0.63	0.48	0.0420	0.09	0.24	0.63
5/13 7:00	20.96	0.54	0.72	0.0449	0.06	0.26	1.94
5/13 19:00	20.70	0.52	0.70	0.0453	0.06	0.23	2.14
5/14 7:00	20.64	0.49	0.68	0.0516	0.08	0.24	2.18
5/14 19:00	17.81	0.48	0.61	0.0526	0.09	0.30	2.17
5/15 7:00	21.76	0.46	0.81	0.0475	0.06	0.28	2.55
5/15 19:00	19.79	0.49	0.77	0.0460	0.06	0.23	2.19
5/16 7:00	16.58	0.56	0.61	0.0406	0.07	0.18	1.60
5/16 19:00	18.50	0.47	0.74	0.0495	0.07	0.23	2.28
5/17 7:00	11.66	0.45	0.36	0.0420	0.12	0.22	1.35
5/18 7:00	9.68	0.53	0.28	0.0209	0.07	0.16	0.58
5/18 19:00	12.73	0.61	0.62	0.0257	0.04	0.23	0.93
5/19 7:00	11.12	0.57	0.62	0.0236	0.04	0.34	0.77
5/19 19:00	20.80	0.65	1.10	0.0340	0.03	0.23	1.38
5/20 7:00	14.65	0.56	0.70	0.0314	0.04	0.21	1.67
5/20 19:00	16.90	0.65	0.87	0.0404	0.05	0.30	1.24
5/21 7:00	15.83	0.62	0.77	0.0384	0.05	0.32	1.30
5/21 19:00	24.55	0.61	0.89	0.0500	0.06	0.19	1.94
5/22 7:00	27.33	0.58	0.96	0.0471	0.05	0.26	2.01
5/22 19:00	25.24	0.50	1.11	0.0464	0.04	0.19	2.52
5/23 7:00	34.44	0.45	1.60	0.0486	0.03	0.21	3.66
5/23 19:00	16.26	0.39	0.97	0.0465	0.05	0.23	2.65
5/24 7:00	9.95	0.35	0.39	0.0372	0.10	0.13	1.46

Table 3 (cont'd)
Summary of Fine Particulate Measurements - HORTRC, May 1988

Ending Date/Time	Fine Particulate Mass ($\mu\text{g}/\text{m}^3$)	Sulfate Fraction	BSP^{-1} ($\times 10^{-3} \text{m}^{-1}$)	BSP^{-1} ($\times 10^{-3} \text{m}^{-1}$)	BSP/BSP Carbon ($\mu\text{g}/\text{m}^3$)	Elemental Carbon ($\mu\text{g}/\text{m}^3$)	Organic Carbon ($\mu\text{g}/\text{m}^3$)
5/25 7:00	6.90	0.50	0.32	0.0233	0.07	0.20	0.00
5/25 19:00	6.42	0.57	0.16	0.0295	0.18	0.04	0.36
5/26 7:00	9.52	0.61	0.32	0.0356	0.11	0.21	0.94
5/26 19:00	7.22	0.56	0.23	0.0429	0.19	0.21	0.86
5/27 7:00	7.75	0.50	0.18	0.0461	0.26	0.20	0.97
5/27 19:00	13.90	0.48	0.28	0.0622	0.22	0.20	1.48
5/28 7:00	16.68	0.55	0.38	0.0730	0.19	0.13	2.48
5/28 19:00	20.64	0.59	0.50	0.0689	0.14	0.26	1.99
5/29 7:00	42.89	0.54	1.22	0.0576	0.05	0.11	1.65
5/29 19:00	27.54	0.58	0.81	0.0584	0.07	0.23	2.26
5/30 7:00	39.68	0.60	1.08	0.0536	0.05	0.18	2.27
5/30 19:00	31.02	0.63	1.09	0.0630	0.06	0.25	2.05
5/31 7:00	43.96	0.57	1.5	0.0611	0.04	0.18	2.89
Mean	17.55	0.53	0.67	0.04	0.08	0.23	1.61
Maximum	43.96	0.65	1.60	0.07	0.26	0.60	3.66
Minimum	0.11	0.35	0.16	0.00	0.02	0.00	0.00
Std. Dev.	9.00	0.07	0.33	0.01	0.05	0.09	0.77

Table 4
Elemental Composition of Fine Particle Samples Collected at HORTRC
Concentration of Elements in Fine Particulates ($\mu\text{g}/\text{M}^3$)

Element	05/03 Night	05/04 Day	05/04 Night	05/05 Day	05/05 Night	05/06 Day	05/06 Night	05/07 Day	05/07 Night	05/08 Day	05/08 Night	05/09 Day	05/09 Night
AL	0.1350	0.1116	0.0554	0.0676	0.0204	0.0650	0.1089	0.1161	0.1235	0.1069	0.1304	0.1363	0.1307
SI	0.1831	0.1506	0.0707	0.0721	0.0300	0.0727	0.1344	0.2121	0.2254	0.1715	0.2011	0.1869	0.2978
P	0.0740	0.0656	0.0364	0.0605	0.0180	0.0503	0.0731	0.0366	0.0568	0.0547	0.0636	0.0775	0.0400
S	3.4017	3.1272	1.5395	2.6795	0.7913	2.1373	3.2724	1.5095	2.3562	2.5204	2.8514	3.2885	1.7079
CL	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
K	0.0607	0.0584	0.0432	0.0282	0.0129	0.0135	0.0324	0.0477	0.0453	0.0391	0.0617	0.0627	0.0558
CA	0.0225	0.0223	0.0103	0.0165	0.0048	0.0093	0.0218	0.0622	0.0547	0.0301	0.0386	0.0241	0.0304
TI	0.0065	0.0054	0.0034	0.0025	0.0019	ND	0.0047	0.0095	0.0052	0.0039	0.0063	0.0052	0.0073
V	0.0019	ND	0.0016	ND	ND	ND	ND	ND	ND	0.0019	0.0016	0.0026	0.0014
CR	0.0026	ND	ND	ND	ND	ND	0.0021	ND	ND	ND	ND	ND	ND
MN	0.0076	0.0062	0.0086	0.0052	0.0038	0.0019	0.0039	ND	0.0028	0.0030	0.0019	ND	0.0044
FE	0.0535	0.0368	0.0187	0.0303	0.0156	0.0148	0.0463	0.0564	0.0594	0.0510	0.0533	0.0499	0.0676
NI	ND	ND	ND	ND	ND	0.0024	ND	ND	ND	ND	0.0018	ND	ND
CU	ND	0.0028	0.0031	0.0027	0.0043	ND	ND	ND	0.0041	ND	ND	0.0022	ND
ZN	0.0105	0.0152	0.0093	0.0087	0.0059	0.0055	0.0146	0.0065	0.0103	0.0073	0.0117	0.0101	0.0044
GA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
AS	ND	ND	ND	ND	ND	ND	ND	ND	0.0034	ND	ND	ND	ND
SE	0.0024	ND	ND	0.0019	ND	ND	0.0015	ND	ND	0.0011	0.0015	0.0016	ND
BR	0.0065	0.0050	0.0024	0.0024	0.0019	0.0017	0.0039	0.0043	0.0034	0.0031	0.0037	0.0050	0.0025
RB	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Y	ND	ND	ND	ND	ND	ND	0.0031	ND	ND	ND	0.0026	ND	ND
ZR	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
MO	0.0099	ND	0.0018	0.0000	0.0020	0.0006	0.0000	0.0019	0.0075	0.0000	0.0000	0.0000	0.0000
PD	ND	ND	ND	ND	ND	ND	ND	ND	0.0067	ND	ND	ND	ND
AG	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CD	ND	0.0046	0.0044	0.0009	0.0040	0.0065	0.0000	0.0134	0.0117	0.0000	0.0003	0.0000	0.0000
IN	ND	ND	ND	ND	ND	ND	ND	ND	0.0077	ND	ND	ND	ND
SN	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
SB	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
BA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
LA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
HG	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
PB	0.0114	0.0074	ND	0.0110	ND	ND	0.0125	0.0097	0.0051	ND	0.0079	0.0066	0.0067

Table 4 (cont'd)
Elemental Composition of Fine Particle Samples Collected at HORTC

Element	Concentration of Elements in Fine Particulates (µg/m ³)												
	05/10 Night	05/11 Day	05/11 Night	05/12 Day	05/12 Night	05/13 Day	05/13 Night	05/14 Day	05/14 Night	05/15 Day	05/15 Night	05/16 Day	05/16 Night
AL	0.0166	0.1008	0.1044	0.1175	0.1341	0.1643	0.1495	0.1425	0.1482	0.1246	0.1058	0.1220	0.1051
SI	0.0516	0.1990	0.2353	0.2056	0.2149	0.3437	0.2542	0.2514	0.2293	0.2018	0.1573	0.2278	0.1975
P	0.0034	0.0584	0.0720	0.0706	0.0937	0.0894	0.0760	0.0657	0.0825	0.0774	0.0683	0.0693	0.0438
S	0.1047	2.5041	3.2055	2.9311	3.7662	3.5661	3.3437	2.8214	3.3599	3.2541	3.0718	2.8866	1.7330
CL	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
K	0.0065	0.0305	0.0289	0.0429	0.0542	0.0649	0.0679	0.0592	0.0526	0.0452	0.0385	0.0615	0.0441
CA	0.0146	0.0267	0.0194	0.0445	0.0346	0.0465	0.0449	0.0765	0.0387	0.0422	0.0225	0.0487	0.0425
TI	ND	0.0019	0.0029	0.0031	0.0066	0.0080	0.0067	0.0080	0.0075	0.0084	0.0041	0.0065	0.0048
V	ND	0.0012	ND	0.0022	0.0022	0.0014	0.0019	ND	ND	ND	ND	0.0013	ND
CR	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.0015
MN	ND	0.0041	0.0058	0.0021	0.0039	0.0024	0.0019	0.0022	0.0028	ND	0.0019	0.0017	0.0024
FE	0.0126	0.0397	0.0359	0.0512	0.0599	0.0691	0.0560	0.0704	0.0526	0.0474	0.0343	0.0607	0.0426
NI	ND	ND	ND	ND	0.0017	ND	ND	ND	ND	ND	ND	ND	ND
CU	ND	0.0046	0.0020	ND	0.0061	ND	ND	0.0019	0.0020	0.0023	0.0020	0.0015	ND
ZN	ND	0.0096	0.0090	0.0071	0.0135	0.0118	0.0097	0.0102	0.0137	0.0077	0.0040	0.0054	0.0052
GA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
AS	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
SE	ND	0.0028	0.0034	0.0028	0.0024	ND	0.0016	ND	0.0012	0.0017	ND	0.0017	0.0010
BR	ND	0.0028	ND	0.0017	0.0024	0.0024	0.0042	0.0040	0.0029	0.0025	0.0026	0.0032	0.0020
RB	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
SR	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Y	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
ZR	0.0000	0.0000	0.0000	0.0000	0.0095	0.0024	0.0042	0.0070	0.0036	0.0029	0.0059	0.0023	0.0073
MO	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
PD	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
AG	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CD	0.0072	0.0000	0.0003	0.0061	0.0036	0.0001	0.0024	0.0046	0.0014	0.0029	0.0000	0.0000	0.0002
IN	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
SN	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
SB	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.0419	ND	ND	ND
BA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
LA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
HG	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
PB	ND	0.0070	0.0048	ND	0.0079	0.0081	0.0069	0.0066	0.0079	0.0049	0.0057	0.0059	0.0051

Table 4 (cont'd)
Elemental Composition of Fine Particle Samples Collected at HONTRC
Concentration of Elements in Fine Particulates ($\mu\text{g}/\text{M}^3$)

Element	05/17 Night	05/18 Day	05/18 Night	05/19 Day	05/19 Night	05/20 Day	05/20 Night	05/21 Day	05/21 Night	05/22 Day	05/22 Night	05/23 Day	05/23 Night
AL	0.0796	0.0721	0.0590	0.1487	0.1015	0.1090	0.1037	0.1732	0.1899	0.1665	0.2128	0.1013	0.0733
SI	0.1942	0.1715	0.1061	0.2814	0.1918	0.1593	0.1311	0.2928	0.3402	0.2623	0.3364	0.2091	0.1316
P	0.0388	0.0536	0.0488	0.0994	0.0650	0.0852	0.0791	0.1095	0.1293	0.1012	0.1182	0.0497	0.0325
S	1.6966	2.5868	2.0961	4.4861	2.7191	3.6620	3.2526	4.9825	5.2769	4.2142	5.2203	2.0952	1.1632
CL	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
K	0.0355	0.0269	0.0224	0.0476	0.0427	0.0293	0.0244	0.0575	0.0540	0.0707	0.0878	0.1113	0.0636
CA	0.0557	0.0170	0.0386	0.0301	0.0239	0.0411	0.0302	0.0656	0.0654	0.0402	0.0346	0.0395	0.0208
TI	0.0052	0.0043	0.0040	0.0065	0.0044	0.0058	0.0033	0.0068	0.0078	0.0073	0.0107	0.0067	0.0048
V	ND	ND	ND	0.0020	ND	ND	ND	ND	ND	ND	ND	ND	0.0017
CR	ND	ND	0.0013	0.0012	0.0019	0.0014	0.0014	0.0011	0.0011	0.0011	ND	ND	ND
MN	0.0054	0.0051	0.0056	0.0039	0.0031	0.0014	0.0020	0.0031	0.0032	0.0032	0.0023	0.0034	0.0025
FE	0.0458	0.0388	0.0369	0.0680	0.0545	0.0415	0.0376	0.0676	0.0612	0.0618	0.0721	0.0508	0.0341
NI	0.0012	ND	ND	ND	0.0024	0.0014	0.0017	ND	ND	ND	ND	ND	ND
CU	0.0027	0.0027	0.0036	0.0023	0.0112	0.0014	ND	0.0020	ND	0.0043	0.0027	0.0019	0.0019
ZN	0.0043	0.0112	0.0091	0.0135	0.0135	0.0084	0.0089	0.0140	0.0135	0.0100	0.0088	0.0084	0.0037
GA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
AS	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
SE	0.0014	0.0021	0.0018	0.0035	ND	ND	ND	0.0019	0.0019	ND	0.0029	ND	ND
BR	ND	0.0017	ND	0.0024	0.0019	0.0034	0.0018	0.0019	0.0019	ND	ND	ND	0.0018
RB	ND	ND	ND	ND	ND	ND	0.0024	0.0034	0.0035	0.0037	0.0033	0.0032	0.0029
SR	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Y	ND	ND	ND	ND	ND	ND	ND	0.0021	ND	ND	ND	ND	ND
ZR	0.0083	0.0000	0.0074	0.0062	0.0000	0.0066	0.0000	0.0027	0.0054	0.0021	0.0000	0.0000	0.0090
MO	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
PD	0.0121	ND	ND	0.0092	ND	ND	ND	ND	ND	ND	ND	ND	ND
AG	ND	ND	ND	0.0087	ND	ND	ND	ND	ND	ND	ND	ND	ND
CD	0.0110	0.0024	0.0044	0.0133	0.0178	0.0076	0.0061	0.0085	0.0159	0.0073	0.0000	0.0008	0.0069
IN	ND	ND	ND	ND	ND	0.0154	ND	ND	ND	ND	ND	ND	ND
SN	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
SB	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
BA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
LA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
HG	ND	ND	0.1458	ND	0.1263	ND	0.1390	ND	ND	ND	ND	ND	ND
PB	0.0061	0.0107	0.0066	0.0087	0.0053	ND	0.0056	0.0065	0.0079	0.0067	ND	ND	ND

Table 4 (cont'd)
Elemental Composition of Fine Particle Samples Collected at HORRAC
Concentration of Elements in Fine Particulates ($\mu\text{G}/\text{M}^3$)

Element	05/24 Night	05/25 Day	05/25 Night	05/26 Day	05/26 Night	05/27 Day	05/27 Night	05/28 Day	05/28 Night	05/29 Day	05/29 Night	05/30 Day	05/30 Night
AL	0.0580	0.0510	0.0688	0.0647	0.0715	0.0892	0.1203	0.1579	0.2355	0.2117	0.2378	0.2115	0.2513
SI	0.0961	0.0849	0.0884	0.1382	0.1159	0.1788	0.1712	0.2730	0.3360	0.3278	0.2884	0.3620	0.3120
P	0.0298	0.0332	0.0514	0.0321	0.0312	0.0533	0.0773	0.1001	0.1737	0.1287	0.1782	0.1483	0.1910
S	1.1400	1.2219	1.9245	1.3509	1.3010	2.2243	3.0801	4.0738	7.6813	5.3656	7.9857	6.5122	8.3707
CL	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
K	0.0253	0.0308	0.0215	0.0342	0.0380	0.0449	0.0452	0.0435	0.0480	0.0823	0.0419	0.0402	0.0495
CA	0.0337	0.0191	0.0283	0.0552	0.0322	0.0375	0.0368	0.0737	0.0414	0.0841	0.0587	0.0934	0.0576
TI	0.0043	0.0030	0.0020	0.0056	0.0047	0.0049	0.0057	0.0080	0.0081	0.0081	0.0077	0.0084	0.0059
V	ND	ND	ND	ND	0.0013	ND	ND	ND	ND	0.0016	ND	ND	ND
CR	ND	0.0016	ND	0.0017	ND	ND	0.0010	0.0013	0.0012	0.0022	0.0013	ND	ND
MN	0.0027	ND	0.0025	0.0034	0.0024	0.0039	0.0047	0.0049	0.0048	0.0041	0.0027	0.0041	0.0034
FE	0.0222	0.0333	0.0367	0.0457	0.0450	0.0570	0.0670	0.0735	0.0632	0.0813	0.0495	0.0751	0.0676
NI	0.0012	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CU	0.0021	0.0018	0.0036	0.0035	ND	0.0033	0.0024	0.0025	0.0090	0.0037	0.0025	ND	0.0031
ZN	0.0026	0.0069	0.0121	0.0111	0.0088	0.0167	0.0188	0.0120	0.0109	0.0097	0.0120	0.0084	0.0119
GA	ND	ND	ND	ND	0.0013	ND	ND	ND	ND	ND	ND	ND	ND
AS	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
SE	0.0023	ND	ND	ND	ND	ND	0.0026	0.0041	0.0067	0.0061	0.0036	0.0030	0.0034
BR	0.0017	0.0014	0.0019	0.0018	0.0027	0.0034	0.0040	0.0056	0.0047	0.0047	0.0047	0.0049	0.0039
RB	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
SR	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Y	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
ZR	0.0059	0.0004	0.0000	0.0061	0.0017	0.0074	0.0000	0.0061	0.0045	0.0035	0.0078	0.0097	0.0030
MO	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
PD	ND	ND	ND	ND	ND	ND	0.0081	ND	ND	0.0095	ND	ND	ND
AG	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
CD	0.0035	0.0055	0.0026	0.0090	0.0088	0.0056	0.0010	0.0062	0.0106	0.0040	0.0000	0.0000	0.0093
IN	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
SN	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
SB	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
BA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
LA	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
HG	ND	ND	ND	ND	0.1447	ND	ND	ND	ND	ND	ND	ND	ND
PB	ND	0.0052	ND	0.0057	ND	0.0054	0.0067	0.0074	0.0137	0.0071	0.0071	0.0080	0.0072

Table 5
Elemental Frequencies¹ in Fine Particulate Samples -- HORTRC, May 1988

ELEMENT	DAY (24 Samples) FREQ., %	NIGHT (28 Samples) FREQ., %	TOTAL (52 Samples) FREQ., %
AL	100	100	100
SI	100	100	100
P	100	100	100
S	100	100	100
CL	0	0	0
K	100	100	100
CA	100	100	100
TI	96	96	96
V	25	25	25
CR	33	36	35
MN	83	93	88
FE	100	100	100
NI	4	21	13
CU	71	64	67
ZN	100	96	98
GA	4	0	2
AS	0	7	4
SE	58	64	62
BR	96	86	90
RB	0	0	0
SR	4	7	6
Y	0	0	0
MO	4	7	6
PD	8	7	8
AG	0	7	4
CD	8	4	6
IN	4	0	2
SN	0	0	0
SB	4	0	2
BA	0	0	0
LA	0	11	6
HG	0	0	0
PB	83	71	77

¹ Percentage of filter samples which contained a detectable quantity of the element. Detectable levels were assumed to be the 2 σ uncertainty in the measurements.

FINE PARTICLE MASS VS. LIGHT SCATTERING

HORTON STATION, VA - MAY, 1988

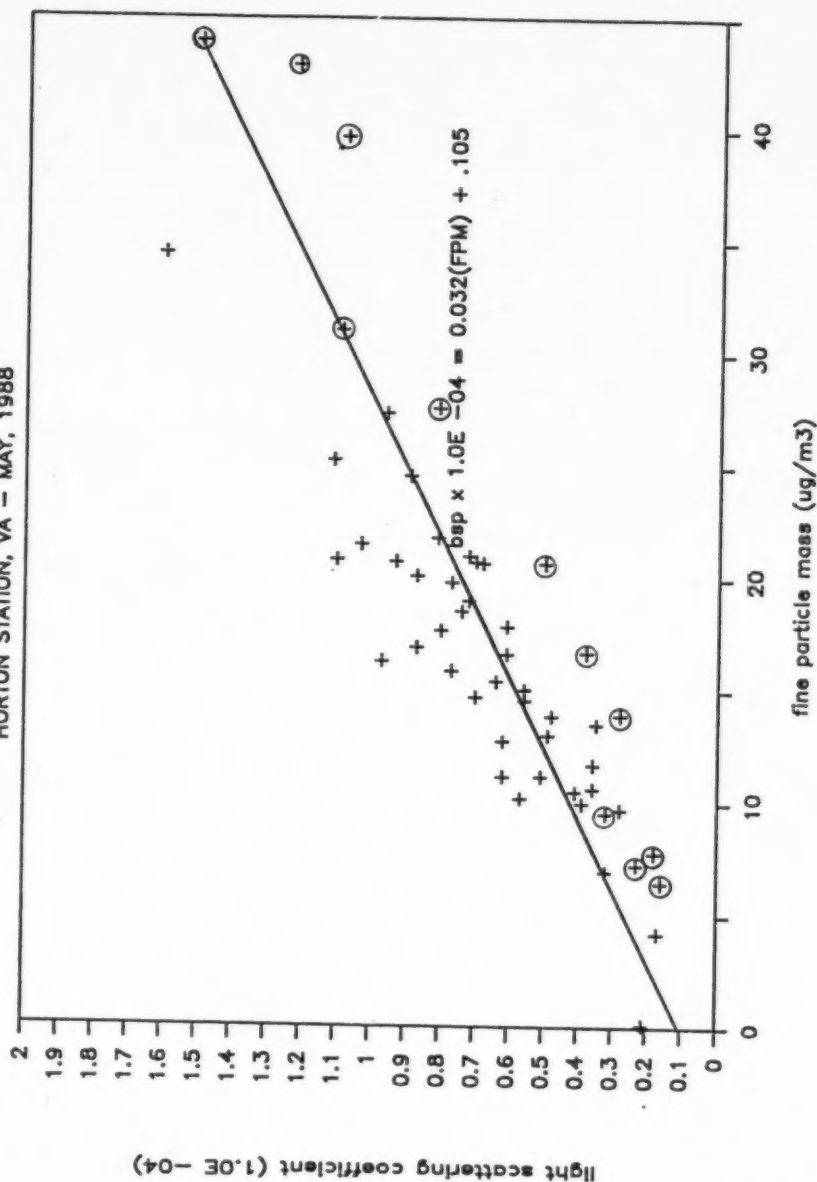


Figure 20. Scatterplot of fine particle mass concentration vs. light scattering coefficient for May 3 -31, 1988. Circled data points indicate measurements made between May 25 - 31, following a cold front which passed on the morning of May 25.

through the region on May 25, the eastern U.S. was persistently under the influence of a stagnating high pressure air mass. Relative humidity measurements were not yet being made at Horton Station at that time; however, one might speculate that lower moisture content was a factor in the relatively lower particle scattering efficiencies (other factors expected to influence the particle scattering efficiency, such as sulfate fraction, did not systematically vary between the air masses).

PHOTOGRAPHIC VISIBILITY MEASUREMENTS

Photographic measurements of standard visual range are related to the extinction coefficient by $B_{\text{ext}} = 3.9/\text{Visual Range}^{16}$. Figure 16 shows the relationship between nephelometry light scattering coefficient measurements and photographically derived measurements of light extinction for the period May 1 - 31, at Perryville, Kentucky. The correlation between the two is not as great as one might expect, the r^2 is only 0.48. Much of the scatter, however, can be attributed to two factors. Most of the data for which light extinction is much greater than light scattering, occur during periods of precipitation. Ideally, data obtained during periods of precipitation should be excluded from this analysis, since precipitation particles are not expected to contribute to light scattering and are not sampled by the nephelometer. Most of the data points for which the light extinction coefficient is less than the light scattering coefficient (a phenomenon which is physically impossible), were obtained at 0900 local time. At this time of day, the atmosphere is not likely to be well mixed.

LIGHT SCATTERING VS. LIGHT EXTINCTION

PERRYVILLE, KY - MAY 1988

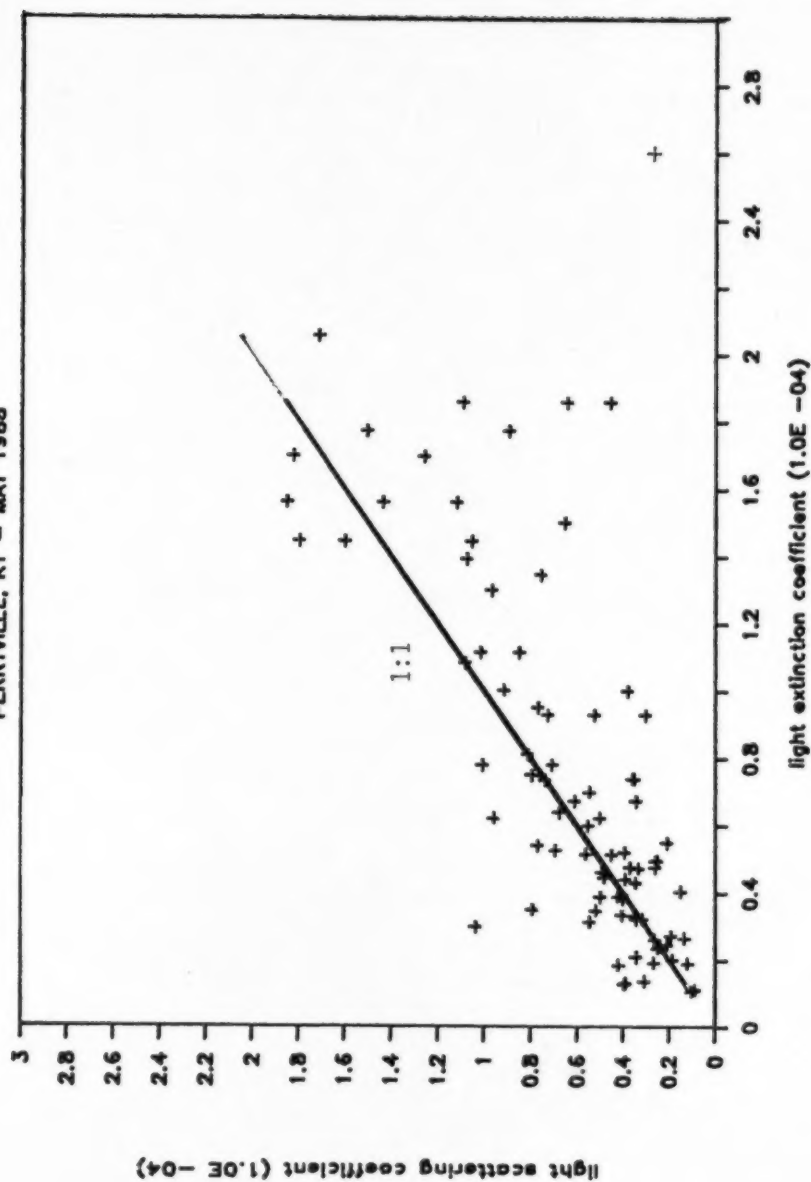


Figure 21. Scatterplot of photographic measurements of light extinction coefficient vs. nephelometry measurements of light scattering coefficient taken at Perryville, May 1 - 31, 1988.

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